Light and Lighting

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Lighting Progress

THIS month we feature a full account of the proceedings at Zürich during the thirteenth session of the Commission Internationale de l'Eclairage. At each of the sessions of the Commission, which are held every four years, recent advances in the science, art and practice of lighting are reported by all member countries, valuable technical discussions take place and subjects for further study are agreed upon. There was a record attendance of delegates to the Zürich meetings and this bears witness to the growing interest in and importance attached to the subject of lighting. There is no doubt about the fruitfulness of the Zürich meetings, and one of the most valuable features of these international gatherings is the informal discussions which occur between individuals from different countries who are concerned with particular aspects of lighting and are doing similar or complementary work. The Commission met under the Presidency of Dr. Ward Harrison, of the United States, whose contributions to the lighting art and long association with the work of the Commission are too well known to need emphasis here. The new President of the Commission is Dr. J. W. T. Walsh, who is equally well known internationally, and we welcome his election not only because we have a national pride in him but because we believe no better choice could have been made.

Notes and News

International Commission on Illumination

In this issue we include a report on the Zürich meeting of the International Commission on Illumination (C.I.E.). We returned from Switzerland with masses of paper and notebooks crammed with information and comments of all sorts. The latter were mainly on the general organisation of the meeting, and though some were most favourable, others (and we must admit that we tend to be rather critical on these things) were not so favourable.

On the credit side we must mention the Kongresshaus, which is an admirable place. The staff at the information desks were most helpful and seemed to cope with any language with ease. The difficulties over hotels sorted themselves out after the first day or so and everyone was impressed with the service given by hotels and shops always with a smile that came so naturally and without any effort or acting. Zürich as a city has full marks, and we are quite prepared to go back and stay there as long as someone is willing to keep us in the standard of comfort to which we are accustomed when we go abroad.

On the other hand, we left Zürich very tired having worked much harder than we had intended—though had we taken part in all the social functions arranged for our relaxation we would no doubt have been completely exhausted. The introduction of simultaneous translation and the reduction of parallel sessions to not more than two was, in our opinion, a mixed blessing. The simultaneous translation worked quite well but it destroyed the intimate atmosphere that we have always considered a feature of C.I.E. meetings; delegates were glued to their headphones and those taking part in discussions assumed that more time was available to them and spoke far too long. The system did, however, permit us to get agreement between different countries on resolutions more quickly. On the matter of time, as two or more subjects had to be dealt with at each morning or afternoon session, the chairman at each session had to set a time limit, as a result of which, in our opinion, few, if any, subjects were dealt with adequately. At these meetings delegates look forward to seeing examples of lighting in other countries, as, for example, the first-class contribution on industrial lighting given by Willard Brown and others at Stockholm. At Zürich there was insufficient time for this.

We know that the secretariat had great difficulty in arranging the programme and it is certain that every delegate would like more time given to his own pet subjects. Nevertheless we can see no point in taking up whole sessions with papers which are of very limited interest; at Zürich some such sessions drew audiences of a mere handful of delegates. We feel that papers dealing with flights of fancy of the mathematicians should have no place in the C.I.E. programme; and how many readers would attend a meeting to listen to a paper on "phenomenological analysis"? (Don't ask us what it means.) Papers on such remote subjects should be submitted for publication within the authors' own countries; the time to include them in the C.I.E. is when they have become of general interest. After all, several hundred delegates had come to Zürich at some expense to someone or other. It was all money well spent but the return could have been bigger.

We must also mention the inclusion of more than one subject in the same report, for example, the combining of school and office lighting; this led to a secretariat report from which it was difficult to pick out either subject and to a discussion which was very hard to follow.

It is, of course, easy enough to criticise—and anyone who takes on the job of organising a meeting of this kind with delegates from 28 countries deserves a gold medal. But we have been frank in our comments because the C.I.E. serves a very useful purpose which has our full support and we make these criticisms in the hope that they may help the C.I.E. to prosper.

One of the attractions about any conference is the opportunity of meeting people, and when these people come from the four corners of the world and meet only once in four years the informal contacts are as important as the business sessions. At Zürich we found so many of our friends who during recent years have contributed to *Light and Lighting* that we arranged a small party for them, and were very flattered that some twenty-five people, representing thirteen countries, were present—including our good friend Ward Harrison, who managed to make one of his rare escapes from the Kongresshaus to join us.

And now we wait until 1959 for the next meeting in Brussels—though we hope the various national committees will not go to sleep until the beginning of that year but will keep things moving so that next time *all* the pre-prints of reports and papers will be available *before* the meeting.

Hard Currency

Lots of people these days take their holidays in foreign parts and quite a few trot around the globe on business. They invariably return with various silver, copper and what can only be called "metal coinage" in their pockets. These coins become a nuisance: they are given to the children to be played with or swallowed or they get scattered about the bedroom or tucked away in drawers. No one likes to throw them away; that would be a waste of hard-earned money and in any case there is always the hope that some day there will be a chance of spending them in their country of origin, though when that chance comes they are forgotten.

The Electrical Industries Benevolent Association (32, Old Burlington Street, London, W.1) has found a way of using this money to increase its funds. By a special arrangement all foreign currency other than copper coins given to the E.I.B.A. can be changed into sterling—and even the copper can be sold for melting down.

The amount of such currency brought back into the country each year is considerable. The E.I.B.A. can use it—you never will—so let them have it.

Light Around Liverpool

One cannot go to Merseyside without noticing how proud the inhabitants of that area are of their achievements. They have every right to be, of course—it is one of the main commercial centres of the world and its by no means least contribution to the war effort was Tommy Handley. It also has something else to be proud of, though it is little known beyond the uncertain boundaries of Merseyside. We refer to the Merseyside Electric Lighting Services Committee which came into being to improve the general standard of lighting, both indoors and out, after the dismal war years.

The committee is supported by the Liverpool Corporation, E.L.M.A., the area electricity board and by the local branches of the I.E.S., E.W.F. and E.C.A. Its activities include the sponsoring of public lectures (it has several times packed the Philharmonic Hall), lectures to schools, institutes and other bodies, and promoting floodlighting. In short, its aim is to bring to the notice of the public the developments which have and are taking place in lighting and thereby to help to brighten homes, work places and public places. It is apparent that the work of the committee during the last few years has had no small effect on the appearance of the city.

As far as we know, Merseyside is the only place in this country where all electrical interests have got together in this way to improve standards of lighting. It is an experiment in co-operation which has succeeded and which other areas might copy.

Street Lighting

The A.P.L.E. annual conference will take place at Folkestone from September 13-16 under the presidency of Mr. J. M. Waldram. The conference sessions will take place in the Leas Cliff Hall and an exhibition of street lighting apparatus will be held in the Langhorne Gardens.

The papers to be given include the following:—

"Local authorities and public lighting," by Granville Berry and W. H. Shaw;

"The code of practice for the lighting of roads other than traffic routes," by J. W. T. Walsh;

"The lighting of tree-lined roads," by H. M. Ferguson and W. R. Stevens;

"The centralised control of street lighting," by J. F. Mackenzie.

A large number of delegates is expected, including several from overseas.

No Street Lighting

Talking about street lighting, do you remember the imaginary folk in Plato's Republic who lived in a subterranean cave and never saw the light of day? Those of us who live in large cities lead an equally artificial existence, for *we* never see the dark of night. Better and better street lighting has made night more and more like day (is that not the aim of the street lighting expert?) and we live in a world without the mystery of dusk or the romance of the stars.

Can we blame, therefore, the good people of Copthorne, Sussex, who for the third time have turned down the proposal that their village should have street lighting? Although, it is true, the main reason for their decision seems to have been that street lighting "is an expensive luxury" (a *scheme* drawn up by a local retired railway worker would have cost them about £40 per year), can it be doubted that, subconsciously at least, the villagers have a desire to preserve, in this artificial age, an island of sanity where the stars still shine and night still casts its welcome blanket over lovers' lane.

"The Printer's Devil"

And talking about lanes and returning to the starless city, those of you who find yourselves in the vicinity of Fetter Lane and feel the need for refreshment might do worse—particularly if like us you are interested in printing—than take that refreshment in a new pub named "The Printer's Devil" which has recently sprung up amongst the ruins of that area. The walls of the bars and restaurant bear various samples of the printers and engravers art whilst the lighting—the excuse for mentioning the place and thus filling these last few lines—is unusual for a pub. An interest in lighting or printing is not essential for admittance.

The central area at London Airport—passenger handling building on left, control tower on right.

International Commission on Illumination

Zürich, June 13—22

By G. F. COLE

The thirteenth session of the International Commission on Illumination (C.I.E.) took place in Zürich from June 13 to 22. The attendance was the largest ever at a meeting of the C.I.E. there being over 520 delegates from 28 countries, including 109 from Britain. The countries represented were: Australia, Austria, Belgium, Brazil, Canada. Czechslovakia, Denmark, Finland, France, Germany, Great Britain, Holland, Iceland, Ireland, Israel, Italy, Japan, Norway, Poland, South Africa, Spain, Sweden, Switzerland, Turkey, United States, U.S.S.R. and Yugoslavia. The leader of the British delegation was Dr. S. English.

Meetings at Zürich were held in the magnificent Kongresshaus, which has every possible convenience for large conferences, including simultaneous translation.

The C.I.E. grew out of the former International Photometric Commission and took its present title in 1913, though the first meeting of the new commission was not held until 1921. At that meeting some 24 delegates represented seven countries. As knowledge of and interest in lighting has grown so has the C.I.E.; not only has the attendance at the meetings, which are held every three or four years, increased, but the scope of its work has widened to cover so many aspects of the production and utilisation of light that it is becoming almost impossible to find time in a meeting of ten working days to deal with all subjects adequately.

The commission is quite independent of any country, government or other organisation, but has grown out of the interest of individuals in different countries who from the beginning have felt that the international exchange of information on lighting is a useful thing. The C.I.E. works through national committees in the various countries which are members; it is from information supplied by these member countries that the secretariat reports on different subjects are compiled for submission at these periodic meetings of the commission. The C.I.E. has no mandatory powers, but it makes recommendations from time to time on matters requiring standardisation and it maintains close liaison with other international organisations such as the I.E.C., I.C.A.O., U.N.E.S.C.O., etc.

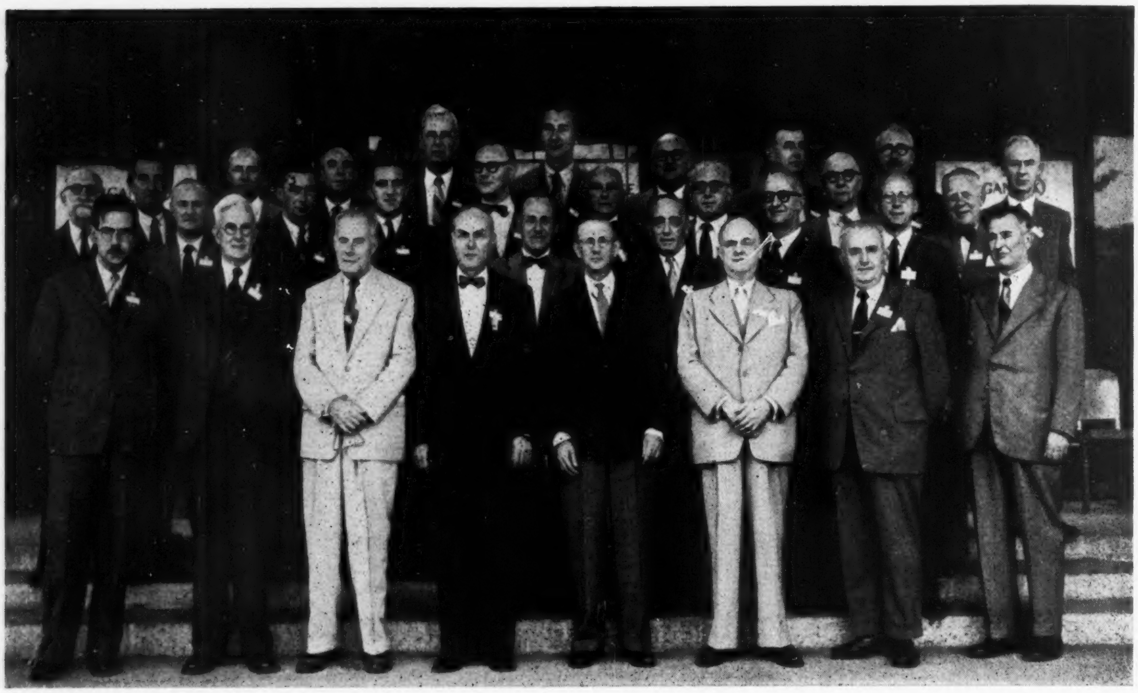
Opening Session

The opening plenary meeting took place on the morning of Monday, June 13, when speeches of welcome to delegates and their ladies were made by Mr. M. Roesgen, president of the Comité Suisse de l'Eclairage, and by Mr. F. Egger, president of the Council of the Canton of Zürich.

Dr. Ward Harrison, president of the C.I.E., then made his opening address. He said that since the 1951 meeting in Stockholm national committees have been formed in Brazil, South Africa, Ireland, Japan and Iceland, all of which countries had been admitted to membership of the C.I.E. National committees had also been formed in India and Yugoslavia. (The application for membership of the C.I.E. by the latter country was approved during the course of the meeting at Zürich.)

Dr. Harrison also referred to the future of the C I.E. He mentioned some of the proposals which had been put forward by the general secretary, Mr. C. A. Atherton, and which included the appointment of a full-time secretary with the necessary staff and office organisation so that the work of the commission might be carried on at a greater rate and thus be made more useful, particularly to users of lighting. These points, he said, were to be discussed in detail by the executive committee during the course of the meeting and it was hoped to make some recommendations at the final plenary session. (See p. 309.)

The office of president of the C.I.E. changes at the end of each plenary meeting, the new president then holding



Officers of the C.I.E. and heads of national delegations.

N. A. Halbertsma, *Holland* — S. Jurov, *U.S.S.R*

R. Aspestrand, *Norway* — W. von Hemert, *Holland* — G. Weber, *Denmark* — A. Dresler, *Australia* — J. Gislason, *Iceland*

R. Deaglio, *Italy* — J. C. Downey, *South Africa* — F. X. Algar, *Ireland*

M. Leblanc, *France* — L. Fink, *Austria* — M. Paavola, *Finland* — Ivar Folcker, *Sweden*

E. E. Wiener, *Belgium* — S. English, *Britain* — T. Oleszynski, *Poland* — L. Smit, *Brazil*

A. Lippestad, *Norway* — A. Tchetchik, *Israel* — P. Fleury, *France* — H. Leuch, *Switzerland*

H. König, *Switzerland* — J. W. T. Walsh, *Britain* — C. A. Atherton, *U.S.A* — W. Harrison, *U.S.A* — A. Brainerd, *U.S.A* — A. R. Meyer, *Germany* — M. Jacob, *Belgium* — D. Matanovic, *Yugoslavia*

office until the end of the next session in three or four years' time. As a rule nominations for president are made at the end of the meeting; this time, however, Dr. Harrison said that the executive committee being unanimous in their recommendation had decided to make their nomination known at the very beginning of the Zürich meeting. Their nominee was Dr. J. W. T. Walsh, of Great Britain; this announcement was received with acclamation by all countries, though the final election did not take place until the last day of the meeting.

After Dr. Harrison an address was given by Dr. Halbertsma, honorary president of the Commission, who spoke of the history and development of the C.I.E.

After the opening plenary meeting the presentation of the secretariat reports and papers began and continued for the next few days. In the account which follows the various subjects are dealt with in convenient groups and not in the order in which they were presented at Zürich. The secretariat reports deal only with progress since the last meeting of the Commission, in this case since 1951.

Light Sources

The secretariat report on light sources has been prepared by Britain for the last two or three meetings, and the report presented at Zürich followed the lines of earlier reports; it summarised developments in all types of light sources since 1951, and gave an extensive bibliography, which makes the report a most useful work of reference. So many types of lamps, some for special applications, are covered by the report that an attempt at a summary here is unlikely to serve any useful purpose. A point of interest, however, in connection with fluorescent lamps is that through the development of methods of process control for both phosphors and lamps, luminous efficiency and life of lamps made in all countries has been greatly improved, so that fluorescent lamps undoubtedly provide the cheapest form of general lighting. For the future work of this committee it is suggested that lamp nomenclature or designation be studied with a view to getting international uniformity, and that attention be given to the problems which have arisen out of the mechanical interchangeability of some lamps which are not necessarily electrically interchangeable.

Sources of ultra-violet and infra-red radiation were dealt with in a separate report which covered the radiant output of different sources, methods of measurement and the main fields of application. As free-burning arc lamps with electrodes of materials other than carbon have come into use, it has been suggested that in future all such sources, including carbon arcs, be known as "free-burning arc lamps."

A number of papers on light sources or problems associated with them were given. A paper on new krypton and xenon filled incandescent lamps was given by R. Penon, of France, in which it was pointed out that the increased availability of these rare gases in France had made it possible to use krypton gas in automobile headlamps, xenon in miners' lamps and both gases in railway carriage

D. M. Finch, Ward Harrison, C. L. Crouch, R. C. Putnam and H. H. Madgsick (U.S.A.).

P. Fleury and M. Leblanc (France), Gen. E. E. Wiener (Belgium). I. Folcker (Sweden) and M. Jacob (Belgium).

A. Boereboom, P. Massart and E. Clausset (Belgium), E. Rebske (Germany) and R. Meyer (Switzerland).

lamps. In all cases higher luminous efficiency and longer lamp life had resulted. A paper on the use of xenon high-pressure lamps in photometry, spectrophotometry, colorimetry, colour matching, etc., was given by H. G. Frühling, W. Münch and M. Richter, of Germany.

The characteristics of electroluminescent cells was dealt with in a paper by H. A. Klasens, of Holland. This paper was a review of progress during the last few years, and the author repeated what has been said so often by other workers in this field to the effect that it will be some time before electroluminescence is even likely to become of much practical value as a light source other than for such things as instrument dials and small signs. He also pointed out that to give a luminous output equal to that of a 40-watt fluorescent lamp several square metres of cells would be required—and then the heat output would be approximately 1,000 watts.

A paper from the United States by E. M. Salter, R. G. Slauer and A. W. Weeks reviewed work done in different laboratories in the United States in connection with the electrical measurement of fluorescent lamps. The authors submitted data which could be used to establish inter-laboratory and international evaluation. A paper on the production and balance of coloured flux for illumination by projection was given by Bezine, Barthes, Tarney and Roger, of France.

Colour Rendering

The main points of the report on colour rendering and colour designation of light sources dealt with the definition of the term "colour rendering property" and its specification, the use of the spectral band and multi-filter methods, the determination of spectral energy distribution and the specification of the colour of light sources, and problems of tolerances. There was no recommendation arising out of the work and report on this subject other than that the work should continue. Three papers on aspects of colour rendering were given: (i) Colour rendering by de luxe fluorescent lamps, by A. A. Kruithof and J. L. Ouweltjes (Holland), (ii) Some proposals on the measurement of colour rendering properties, by Mme. Roy-Pochon (France), and (iii) An appraisement of the colour rendering properties of fluorescent lamps, by T. Azuma and L. Mori (Japan).

Basic Quantities

The report on basic quantities for which France is the secretariat country, gave the results of inquiries on revised definitions proposed at the 1951 meeting in Stockholm. This resulted in a long list of recommendations many of which, no doubt, will be incorporated, if they have not already been incorporated, in the revised International Lighting Vocabulary the draft of which, subject to some minor editorial corrections, was approved at Zürich. (National committees are given until January 1, 1956, to make any further comments on the draft after which the final form of the vocabulary will be prepared for publication.)

The report on photometry indicated that physical methods are now used in preference to visual photometry and the properties of the more commonly used physical receptors were indicated. Attention was also drawn to possible errors in flux comparison with the use of the Ulbricht sphere. During the next four years national committees have been asked to carry out photometric and colorimetric intercomparisons with the object of determining the consistency of the measurements made in different countries on tubular fluorescent lamps. An extensive bibliography giving over 450 references is included with the report.

The colorimetry report (prepared by the U.S.A.) included recommendations for the choice of a standard chro-

maticity diagram and for symbols by which colour matches may be expressed in vector notation. The report also discussed standard sources for colorimetry of fluorescent materials, a standard method for measurement and specification of whiteness and standard angular conditions of illumination and viewing for the colorimetry of opaque specimens.

Vision

The fundamentals of vision and the visual aspects of lighting figured prominently at Zürich, and the first afternoon was given over to three papers on these subjects by speakers from the United States and from Holland. The first of these was by C. L. Crouch, technical director of the American I.E.S., who reviewed visual research as related to illuminating engineering in the United States. He pointed out that the illuminating engineer is becoming increasingly sensitive to his responsibility for providing not only the quantity of illumination on the task, but also for providing a visual environment conducive to optimum perception, comfortable surroundings and pleasing atmosphere. The results of earlier work have so affected design that a planned comprehensive programme of research is now being carried out, the first efforts having been devoted to a study of colour appearances and colour preferences. The paper went on to describe the type of research now being done.

The second paper by C. J. Fortuin and J. J. Balder, of Holland, dealt with the influence of time of observation on the visibility of stationary objects (Landolt rings). In addition to the determination of the influence of observation time, the effect of the age of the test subject has also been measured. (This paper would appear to confirm the results obtained by Weston as reported to the I.E.S. and at the 1951 meeting of the C.I.E.)

The third paper in this series was by H. R. Blackwell, of the United States, on the use of visual brightness discrimination data in illuminating engineering. Visual brightness discrimination data were reported in which ranges of values of field luminance, target size and target exposure time were studied. Methods were also described by which the data may be used to evaluate the effects of quantity and quality of illumination on the speed and accuracy of visual performance. Suggestions were also made by which similar data may be used to evaluate highway visibility in night driving.

The reports of the secretariat on photopic and scotopic vision and that on glare and adaptation were presented at the same meeting. As a result of discussions on the former it was recommended that in every practical application in which scotopic vision is believed to play a significant part, both scotopic and photopic photometric values be given The report on glare and adaptation consisted mainly of a bibliography as work on these two phenomena is still in progress. As far as adaptation is concerned the view is now held that besides the photo-chemical process there is also an important nervous component which determines many features of the eye's behaviour. A paper on new investigations on the observation threshold of the eyes was given by P. Jainski, of Germany, and another on the physiological bases of disability glare by G. A. Fry, of the United States. In a paper on the visual function of the retinal periphery, also delivered in this session, R. A. Weale, of the Institute of Ophthalmology, London, said that though more attention in the past has been given to foveal vision, peripheral vision is equally important as it is upon this that vision at low luminance levels and perception of movement depend.

Interior Lighting

Comfort in Lighting

The practical problems of glare were discussed by a number of the technical committees concerned with lighting applications; glare was also one of the main items of discussion in the committee on comfort in lighting. The report on this subject had been prepared by Australia, and opened with an analysis of the concept of "comfort in lighting" and listed the factors considered to be most important; it was suggested that direct discomfort glare from luminaires is the factor which most deserves international study at the present stage and the report, therefore, dwelt on this aspect in some detail. As a result of the discussion on the report it was agreed that the C.I.E. should prepare international tables for the evaluation of direct discomfort glare. It was also agreed that the work on this subject should be extended to include a study of "pleasantness in lighting" in addition to consideration of "comfort" Following the discussion on this report a paper on subjective additivity of areas of brightness was presented by S. K. Guth, of the United States.

Predetermination of Illumination and Luminance

The comprehensive report on this subject prepared by the U.S.A. included a most useful bibiography. The quantitative design of lighting installations becomes more and more complex as new knowledge of criteria becomes available and as new light sources, luminaires and techniques are developed. This committee was set up at the 1951 meeting to study the various methods in different countries and to record new methods and new work. The report presented at Zürich is therefore the first of its kind and forms a very useful piece of documentation. Associated with this report were two papers. H. Zijl, of Holland, in his paper said that though the classical utilisation tables of Harrison and Anderson continue to be of good service the need has arisen for something more than the simple numerical data at present available. He therefore put forward new basic data which can be presented in the form of tables or graphs for the convenience of users. The other paper was by J. Dourgnon, of France, in which he made a comparison between his own method of determination of utilisation factor with the method of Moon and Spencer.

A further paper on the design of interior lighting was given by J. M. Waldram which summarised the papers on the design of the visual field and on a new approach to interior lighting which have been published in the I.E.S. Transactions.

In its recommendations the committee on predetermination urged that study be given to the preparation of data on maintenance factors so that more consistent and accurate figures might be made available.

Factories

The report on industrial lighting was the responsibility of the British Committee and described developments in industrial lighting practice since 1951. As might be expected fluorescent lighting, particularly with hot cathode lamps, is being increasingly used. For a number of years the importance of upward lighting has been realised in Britain and it would now seem that most countries also appreciate this point; in fact it would appear that all countries now realise that one of the most important factors in industrial lighting is the comfort of the workers. It is reported from the U.S.A. that for lighting of foundries and other industrial areas where dirt and dust rapidly reduce the efficiency of luminaires some installations of internally silvered lamps have been made. As in many other branches of lighting maintenance is now being given much more attention than in the past.

Though it is generally realised that improvements in factory lighting have beneficial results, no factual information on this has so far been produced. A speaker from

A. G. Higgins, H. Dance, F. C. Smith, W. R. Stevens and C. Padgham (Britain).

Left: J. A. De Artigas and J. Borrego-Gonzalez (Spain).

Right: H. Leuch (Switzerland) and I. Folcker (Sweden).

Left: E. Paivarinne (Finland) and Th. Wakefield (U.S.A.).

Right: J. C. Downey and H. D. Einhorn (South Africa).

A. Roberts, D. A. Strachan, N. Slater, S. English and J. Mortimer Hawkins (Britain).

America quoted one installation in a heavy engineering plant where an improvement from 5 to 20 lm/ft^2 had resulted in a reduction of 32 per cent. in accidents with a further reduction of 16 per cent. on redecoration of the premises. The effects of decoration as well as lighting were mentioned by many speakers in the discussion. It was agreed that during the next four years the secretariat on industrial lighting should try to obtain data on the effect of improved industrial lighting on such things as increased production, reduction in waste or higher quality of products, reduction in accidents and the effect on the morale and health of the workers. The secretariat will also make a study of colour conditioning and the importance of colour schemes in industrial premises.

A somewhat specialised branch of industrial lighting is the lighting of hazardous or corrosive situations which formed the subject of a separate report, also prepared by Britain. This is a new subject of study by the C.I.E. and it was obvious from the report that it is one of great importance. Though closely allied to industrial lighting the problems are more concerned with the electrical, mechanical and chemical properties of fittings. Once again the question of maintenance is of importance as it is essential that all fittings which are to operate in hazardous locations should be readily accessible and adequately maintained. As this is a new subject of study the present report does little more than draw attention to different types of industrial hazard likely to affect lighting installations and to make some attempt to classify lighting equipment. It is acknowledged that in its present form this classification is far from complete, but it is hoped that it will form a useful basis for the preparation of a more authoritative classification. During the next few years it is intended to give some thought to the preparation of an international terminology and internationally agreed tests for various classes of lighting equipment designed to operate in hazardous situations.

Schools and Offices

These two subjects were dealt with by one committee and were covered by the same report. This makes it a little difficult to deal with either of them separately—or indeed adequately. Once again the question of maintenance comes to the fore as it would seem that in both schools and offices the matter is usually overlooked. In the course of the discussion it was reported that the French ban on fluorescent lighting in schools which had been imposed in 1950 had now been removed but the new regulations drew attention to the question of maintenance, brightness ratios and the avoidance of flicker. It would seem that flicker and hum are the two main disturbing factors of fluorescent lighting in schools and offices, though it is pointed out that these do not occur in good installations. The programme of work during the next four years for this committee includes the study, in collaboration with the daylight committee, of the question of daylighting in offices and schools both alone and in combination with artificial lighting.

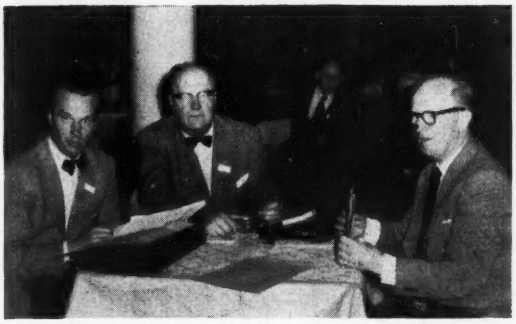
Homes and Hotels

These two subjects were also combined in one report which dealt mainly with levels of illumination used in various parts of homes and the efforts being made in different countries to bring about an improvement in home lighting. It was indeed generally agreed that in all countries home lighting is a subject which has largely been ignored during the last few years. It was apparent, however, that attention was now being given to this and it was reported that in Switzerland a campaign had been arranged by electricity supply undertakings in an effort to encourage householders, as a first step towards getting better lighting, to use larger-sized lamps. It had been found in this case by using

Top :—
C. L. Crouch (U.S.A.), H. C. Weston (Britain) and S. Guth (U.S.A.).

Centre :—
E. Wittig, H. Helwig and W. Kohler (Germany).

Bottom :—
Group of delegates from the U.S.S.R.



Top :—

K. Wessel, R. Eger (Norway) and E. Olsen (Denmark).

Centre :—

P. T. Cahill, W. R. Stevens and D. R. Campbell (Britain).

Bottom :—

I. Folcker (Sweden), J. M. Waldram (Britain) and A. Boereboom (Belgium).

properly trained staff who were able to talk "lighting" to domestic consumers that excellent results had been achieved. It was apparent from the discussion on home lighting that it was thought that one of the best approaches to domestic consumers was through the electricity supply undertakings with whom they already have direct contact. It was also pointed out that the domestic lighting load was one of considerable importance to supply undertakings who should, therefore, take far greater interest in this matter. The importance of adequate wiring was also stressed.

This report was illustrated by examples of home and hotel installations. The illustrations, however, seemed to have been badly selected, particularly two representing interiors of houses which were credited to Britain.

The following recommendations on home lighting were agreed:—

(1) that as the average illumination in a room of a home is of little interest it is recommended that in future illumination values be quoted for various activities in a home.

(2) As calculations and measurements are seldom made in home lighting, in future wattages or light outputs of lamps for the principal luminaires in order to give the illumination required for specific activities should be stated.

(3) that close co-operation be maintained with architects and electrical contractors to ensure suitable wiring installations.

(4) that the improvement of lighting in the home be actively promoted by all appropriate means.

There was not a great deal of discussion on hotel lighting, mainly perhaps because it was felt that there was little lighting to be discussed. Indeed, it was agreed that during the next few years, since hotel lighting so seldom conforms to good practice, that all appropriate means be employed to bring about an improvement. It was also agreed to draw up a table of recommended values of illumination for the public rooms and bedrooms of hotels.

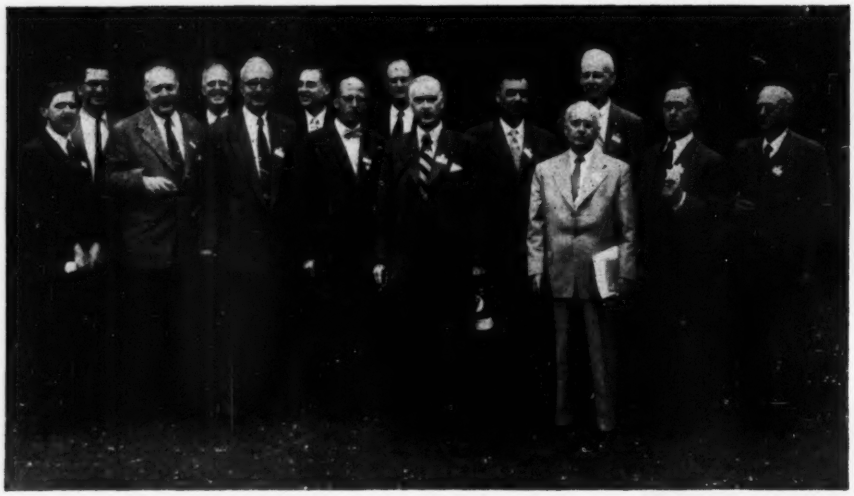
Shops

A quite useful summary of modern practice in shop lighting was prepared by the French committee. Practice in different countries seems to be very similar and in most good modern installations general lighting is provided by fluorescent lamps with local or emphasis lighting by reflector spot lights. Use is also sometimes made to good effect of indirect lighting or luminous ceilings with crystal glass chandeliers. The fluorescent lamp, however, does appear to have become the predominant light source for shops; in fact it would appear that most shops in what are known as "shopping centres" now make use of these lamps. One of the greatest difficulties, however, is in the choice of colour. The general preference appears to be for lamp colour temperature around 4,000 deg. K., but it would seem that it is essential to standardise the colours of fluorescent lamps and their designations as quickly as possible.

On the lighting of shop windows it would appear that the levels of illumination have now risen to such an extent that it is doubtful whether further increases can be achieved without serious overheating within the window. According to the report general levels of from 300 to 500 lm/ft^2 are common, and these are often augmented by projector lamps which may give anything up to, as in the United States, 2,000 lm/ft^2.

Indoor Games

This report, prepared by Sweden, gave details of practice in different countries for various games. Lighting requirements vary according to whether the games are for training,



Editors and representatives of lighting journals at Zürich.

From left to right: J. Jansen, Holland (*International Lighting Review*); G. F. Cole, Britain (*Light and Lighting*); M. Cohu, France (*Lux*); Willard Brown, U.S.A. (*Light*); A. Dresler, Australia (*I.E.S. Lighting Review*); C. L. Crouch, U.S.A. (*Illuminating Engineering*); H. Leuch, Switzerland (*Bulletin de l'A.S.E.*); E. Sawyer, Britain (*ELMA Lighting Service*); G. R. Hassel, Sweden (*Ljuskultur*); R. Nampon, France (*Sodel*); W. Arndt, Germany (*Lichttechnik*); N. A. Halbertsma, Holland; F. Taute, Germany (*Lichttechnik*); J. Wetzel, France (*Lux*).

recreation or are in the competition class. For the latter, the lighting requirements are much more critical not only for the players themselves, but also for the spectators. In ball games and other sports in which attention is focused on a small object, the aim is to get good contrast between that object and the background. This can be done by different colour or different brightness or both, and it was pointed out that light sources and fittings in the field of view must be avoided, and care must be taken in their siting to ensure that they cannot form a background to the ball. It was also pointed out that vertical illumination is just as important as horizontal illumination. Things which have to be avoided include flicker and specular reflecting surfaces in the field of view.

Public Buildings

The report on lighting of public buildings covered a wide range of subjects, including museums, art galleries, exhibition halls, churches, theatres, cinemas and restaurants. On museums and art galleries the practice in different countries was summarised; in most of such buildings, of course, the principal source of light is daylight, but artificial light is installed in almost all cases, though often only as a supplement to daylight. Among particular studies which were reported was included the lighting of showcases by fluorescent lamps; the control of heat in showcases is of considerable importance as temperature has considerable effect on the deterioration of exhibits. It will be recalled that about three years ago considerable alarm was felt about the possible ill-effects of fluorescent lighting on museum exhibits. This problem has been studied in several countries and it is now reported authoritatively that more damage is done by daylight than by light from fluorescent lamps.

The programme of study for this committee for the next four years includes the accumulation of as much information as possible on the lighting of painting, sculpture and other works of art in the hope that such information can be published as a guide to directors of museums and art galleries.

The section on churches included typical examples from many countries. Many different techniques are used, which goes to show that church lighting cannot easily be codified. Basic requirements may be very similar, but methods and techniques employed may vary considerably and yet give good results. Church lighting would appear to be one field where the fluorescent lamp has not yet intruded to any extent.

There was very little to report under the lighting of cinemas and theatres, though a number of examples of auditorium lighting were given. There have been, however, few developments since 1951, as few new theatres have been built.

For the lighting of restaurants and cafés it was again seen that modern practice is to provide general lighting by fluorescent lamps with tungsten lamps, either as spot lamps to give accent lighting and to improve colour rendering, or in decorative features. It is apparent in this field that lighting is being incorporated by architects as an integral part of the interior. It is reported that cold cathode lighting appears to be used mainly in the popular type of café or milk bar. Hot cathode lamps are used in the better class of restaurant, and it would appear that preference is almost universally for a warmer colour lamp which will blend well with tungsten lighting. On the whole, however, the colour-rendering problem in restaurants does not seem as acute as it was a few years ago; this is probably due not only to the fact that new colour lamps are available, but as experience is gained, less mistakes are made.

Associated with this report was a paper on the fundamentals of museum lighting by L. S. Harrison (United States), in which the author recommended that colour temperatures should be around 4,000 deg. K. with a spectral composition as near continuous as possible, paintings to have a relatively high illumination, vertical and horizontal illumination to be approximately equal with vertical lighting falling at an incident angle of about 30 deg. from the vertical to avoid shadows from frames, and to avoid obscuring tapestry designs by textural shadows whilst diverting most specular reflections from varnish or protective glass to the floor.

Stage Lighting

The report on stage lighting was prepared by Britain and from it it would appear that the main developments since 1951 are in the improvement and further development of control equipment. From Germany, however, it is reported that 1-kw and 2-kw high pressure xenon air-cooled lamps

Top:
A. Dresler (Australia), S. English (Britain) and F. X. Algar (Eire).

Centre:
R. Nampon, P. Fleury, Yves Le Grand and J. Chappat (France).

Bottom;
A. G. Penny, W. E. Harper, F. Widnall and J. Cowan (Britain).

have been used for spot lighting and optical projection, whilst the 6-kw water-cooled xenon lamp is used for the floodlighting of cycloramas. It would appear that little headway is being made with fluorescent lighting on theatre stages though this light source is also being used for cyclorama lighting. From the discussions on this subject it was agreed that each country should encourage the inspection authorities to make their regulations consistent with the lamp manufacturers' standards prevailing in all countries.

Television and Cinema Studios

The main contributions to this report were received from Britain, Germany, France and the U.S.A. The United States contribution was confined to lighting for colour television production and was of particular interest as this is the only country in which colour television is in regular use. Incandescent lamps are mainly favoured for colour television production on account of their continuous spectrum, their relatively low cost and long life, and because they are available in a wide range of sizes with approximately the same colour temperature. Colour temperatures of 2,900 to 3,200 deg. K. are used. Basic lighting levels are 300 to 500 lm/ft^2. Lighting loads of between 75 and 100 watts per square foot of studio area are provided with one electrical outlet per 8 square ft.

The British contribution formed a concise and useful summary of lighting practice in TV and cinema studios and in the discussion reference was made to the new colour carbons which had recently been produced in this country. It was understood that these carbons were now being used in Hollywood studios and were giving very good results and are likely to be used extensively for colour film work. Xenon high pressure lamps have also been tried out in the U.S.A., but their colour temperature of 6,000 deg. K. has to be reduced by filter to the current standard of 3,200 deg. K. It is understood that these lamps have also been used in Germany for basic lighting in black and white television.

Much of the discussion on this subject was on the standardisation of colour temperature for film and television work. Most film studios have now standardised at 3,200 deg. K. and it was pointed out that it would be an advantage if television studios adopted the same standard. The question of the use of fluorescent lamps for television production was raised by a Yugoslav delegate who reported that unsatisfactory results had been obtained with these lamps. Technicians from both Britain and the U.S.A. said that from early tests with these lamps it had been decided that they were unsatisfactory for television work.

An important point in connection with television studio lighting is the avoidance of excessive heat and with colour television this is already becoming a great problem and there would appear to be a need for a cooler operating light source.

Hospitals

The report on hospital lighting prepared by the National Committee of Finland dealt with lighting of wards and the lighting of operating theatres. Lighting fittings for wards should be of simple design and easy to handle and clean and also of pleasing appearance. It is important also that fittings should be such that they do not produce disturbing brightness patterns on walls or ceilings, in fact that they do not in any way become a source of irritation or disturbance to patients lying in bed. The most common light source in wards is the tungsten filament lamp though examples of fluorescent lighting were quoted; in the latter case, however, it was suggested that it was essential for the ends of the lamps to be shielded to avoid any possibility of flicker.

The problem of operating theatre lighting has given rise to a number of investigations and experiments during recent years. The presence of lighting apparatus suspended above the operating table cannot but help acting as a dust collector

A. Tibaldi, C. Passerini, L. Richard and L. Novelli (Italy).

A. Tchetchik (Israel), J. Gislason (Iceland), M. Paavola (Finland) and J. C. Costello (Ireland).

W. M. H. Rennhackkamp and J. C. Downey (South Africa) and A. A. Brainerd (U.S.A.).

J. Rieck (Germany) and L. Fink (Austria).

V. Muljevic (Yugoslavia) and E. Rebske (Germany).

and it is essential therefore that the surfaces of such apparatus should be as simple as possible and regularly cleaned. To avoid this trouble systems have been tried out, particularly in France, of lighting projectors fitted in the ceiling of the operating theatre and controlled from outside the room. Such systems reduce the risk of disturbing the surgeon or his assistants as well as the risk of polluting the atmosphere of the room.

National committees have been asked to make a study of the following points: (1) The maximum average luminance value on the visual field of the patient which will allow him to rest and relax. (2) The ratio of the highest luminance in the visual field to the average luminance which does not cause discomfort, and (3) the necessity in the examination of patients of reproducibility of colour rendition of fluorescent lamps.

Exterior Lighting

Street Lighting

The report on street lighting was prepared by the British National Committee. Though a great number of new installations of street lighting have been made in different countries most of them have been on somewhat conventional lines, though many of them show national characteristics. Mounting heights for traffic route lighting are usually between 25 and 30 ft. There is a tendency for spacings to become somewhat shorter and good practice now is usually between 100 and 120 ft. Some Italian and German installations use very short spacings especially with fluorescent lamps parallel to the street axis. High pressure mercury vapour lamps with improved fluorescent coatings are also coming into use. In America, Belgium and France several bridges have been lighted by continuous fluorescent lamps arranged in the parapets at low mounting height in order to avoid the use of lighting columns. Practice in lantern design continues to show distinct national characteristics and many Continental countries still favour lanterns inclined towards the centre of the road.

Some countries now have codes of practice on street lighting though their form and the amount of information or guidance they give varies.

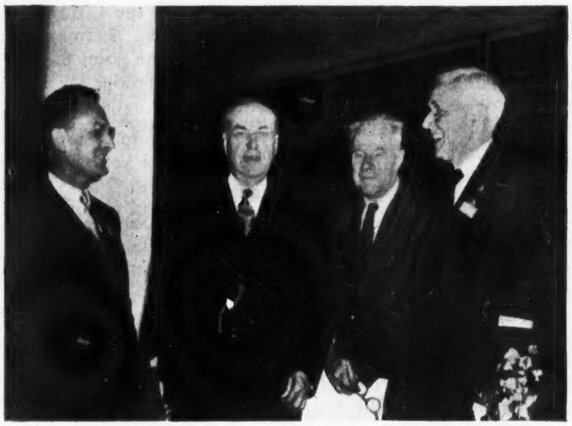
There was some discussion on costs of various types of street lighting systems, but it is very difficult to compare costs in different countries; Germany reported that fluorescent and sodium lighting were the two cheapest systems and that the higher capital cost of a fluorescent installation is paid off in about three years by the saving of energy. There would appear to be a need for a standardised system which can be used for the purpose of comparing costs so that engineers in different countries can easily appraise the cost of a given system under their own conditions.

At this session a number of papers were given. J. B. de Boer, of Holland, gave a paper on the influence of the colour of lighting on discomfort glare in which he reported experiments, with a laboratory model using sodium, mercury fluorescent and incandescent lamps. Observers showed a definite preference for the warmer coloured light sources: the results obtained differed from those of previous work, but it was thought that the differences could partly be ascribed to the differences in technique. A paper by Paul Massart,

of Belgium, on study of brightness in street lighting also described some model tests.

A paper by J. C. Tanner and A. J. Harris, of the Road Research Laboratory, described some recent British investigations into street lighting and accidents. The relationship between street lighting and accidents at night has been discussed at previous meetings of the Commission but this is the first time that any evidence has been put forward from Britain. Nevertheless, the authors throughout the paper stressed that the results quoted, though pointing in the right direction, were really based on insufficient data. One of the purposes of the paper was to indicate that knowledge on this subject is very incomplete and to urge more research on this problem.

Aspects of street lighting to be studied by national committees during the next few years include the compilation of data on road surfaces, and the collection of data on accidents in lighted streets. At the 1951 meeting of the Commission it was also agreed to study methods of appraising visibility on the road. A number of so-called "visibility meters" have appeared, but it is felt that there are theoretical difficulties in the way of measurement of visibility in a street as commonly understood. It was therefore agreed that "visibility" and "revealing power" should be defined more closely, after which it should be decided whether further work is necessary. It was also thought that if a criterion on visibility can be found this might be applied to a determination of the conditions in which traffic can be permitted to travel without headlights or passing lights.



Yves Le Grand (France), Ward Harrison (U.S.A.), C. Atherton (U.S.A.) and J. W. T. Walsh (Britain).

Outdoor Sports

The report on this subject was very disappointing and gave very little information on what is an important subject which has grown rapidly during the last few years. It would appear that only in the U.S.A. is there a code for lighting for outdoor sports though in many other countries there are plenty of floodlighting installations, particularly for football. From all the evidence that is now available it is reasonable to expect that some information on suitable types of projector, mounting heights, lighting loads, etc., could have been given and some guidance given on the important matter of the avoidance of glare.

Railway and Dock Lighting

This report, prepared by Britain, covered the interior and exterior lighting of railway and dock premises and the lighting of passenger trains. A brief review of recent developments and current trends was given. The report, however, was a condensed version of a much longer draft and much of the information available was, therefore, omitted. Of topical interest in view of the proposed change from steam locomotives to diesel locomotives in Britain was the description given of the lighting of diesel electric locomotive sheds in the U.S.A., where illumination levels are usually between 30 and 50 lm/ft^2. The sheds are usually of the through-type in which the locomotive enters at one end, is serviced, and leaves at the opposite end. The lighting consists of pit lighting, by filament lamps in vapour-proof fittings recessed into the walls, combined with continuous rows of angle type dust-tight fluorescent units located under the floor level platforms in such a manner as to direct the light on to the running gear. General lighting is also provided for the platforms.

Lighting in goods sheds, where it is necessary to light the sides of vehices so that labels can be identified and read, seems to be a permanent problem. It was thought that fluorescent lighting offers the best solution.

Mine Lighting

A very useful report on mine lighting was submitted by Belgium. This is a subject which has received a lot of attention in recent years particularly by those countries whose economy is based to a greater or less extent on the mining of coal. The problems are not the same in all countries, however, as mine conditions vary. In Britain during the last five years the number of electric hand lamps has decreased by 80 per cent. in favour of cap lamps and at present 92 per cent. of portable lamps are of the cap type. A far greater proportion of portable lamps is used in Britain than in any other country. The use of pneumatic electric lamps is slowly increasing in Britain. Papers at this session were given by Dr. W. J. Wellwood Ferguson, who expanded the information he presented at the 1948 and 1951 meetings on dark adaptation and miners' nystagmus; by W. Young, E. L. J. Potts and W. B. Bell (all from Durham University) on a lumen method of design for mine lighting installations, and a paper on visibility in mines by N. Pattigny, of Belgium.

Future work of this committee is to deal with (1) cost of underground lighting, (2) a study of the problems of underground visibility, brightness contrast, etc., (3) study of optics of lighting equipment in order to improve light distribution and to minimise glare, (4) investigation of the developments of toughened diffusing glass and acryllic covers on lighting fittings, (5) the establishment of a comparative international standard for krypton filled miners' lamp bulbs with a flux of between 20 to 50 lumens, (6) study of the application of cold cathode fluorescent tubes operating at frequencies of around 400 cycles in order to reduce size, weight and cost of equipment, and (7) to study the relation of underground lighting to the frequency and nature of visual functional disorders.

Lighting Codes

A committee on lighting legislation, codes and recommended practices was set up at the 1951 meeting of the C.I.E. and it presented its first report at Zürich. As far as legislation is concerned the report dealt briefly with such regulations as exist in different countries to secure minimum levels of illumination in industrial premises to avoid accidents. As with many other committees concerned with lighting practice the importance of proper maintenance of lighting installations was discussed; most countries now seem to be giving this some attention and is was thought that where regulations for lighting are laid down some guidance on maintenance should also be given.

The main discussion at this meeting however was on lighting codes and recommended levels of illumination. At the 1951 meeting in Stockholm all member countries of the C.I.E. were recommended to study the basis of visual performance and ease of seeing adopted in the British I.E.S.

Code. Many countries have in fact since done this and issued either new codes or revised editions based on the British code; several other countries are in course of preparing new codes.

It is well known that recommended levels of illumination are higher in the U.S.A. than in Britain; the reason for this is, however, not always appreciated by users who cannot understand why two different levels can be recommended for the same visual task. The reason is that economic conditions in the U.S.A. permit the adoption of a higher standard of visual performance—98 per cent. in the U.S.A. against 95 per cent. in Britain. To obtain this slight increase in *visual* performance means that illumination levels have to be doubled or trebled and the view is taken in Britain, and in many other countries where economic conditions are similar, that the additional installation and running costs are not justified. Those countries which are now faced with the task of preparing a national code naturally study the codes of other countries which have been in force for some time and they have to decide which code to follow. The fundamental basis of these codes is, of course, the same (see H. C. Weston, "Lighting Codes" *Light and Lighting*, July, 1955, pp 232-4) and it was decided that the C.I.E. should prepare a table of scales of values of illumination on the basis of adequacy for several levels of efficiency of visual discrimination for each of a series of grades of visual task ranked according to their difficulty. Each country could then select any level of visual efficiency for any task and could quote the international scale to explain why any particular level of illumination has been recommended.

Daylight

The study of daylight is a subject which has been pursued vigorously by the C.I.E. for a number of years and an intermediate meeting was held in 1953. A report of this meeting (see *Light and Lighting*, July, 1953, p. 278) was included in the secretariat report which was prepared by Australia and presented by Dr. A. Dresler. The report forms a very useful summary of work on daylighting since 1951 and gives a bibliography of over 100 references. Also included is an historical outline of the concepts and terminology of daylight prepared by R. O. Philips, of the New South Wales University of Technology.

The discussions at Zürich are perhaps best summarised in the recommendations which were adopted. These are:—

(1) A revised definition of Daylight Factor as a measure of the daylight illumination at a point on a given plane expressed as a ratio of the illumination on the given plane at that point and the simultaneous exterior illumination on a horizontal plane from the whole of an unobstructed sky of assumed or known luminance distribution. Direct sunlight is excluded from both interior and exterior values of illumination.

(2) That consideration be given to the breakdown of daylight factor into (a) sky component (b) external reflected component, and (c) internal reflected component.

(3) Gives recommended provisional definitions of the terms used in (2).

(4) That wherever daylighting design is based on an overcast sky, the basis for calculation and measurement should be that the ratio of the luminance of the sky at an altitude θ above the horizon to the luminance at the zenith is taken as $\frac{1 + 2 \sin \theta}{3}$ unless it is known that some other luminance distribution applies.

(5) That national committees not interested in basing design solely on the overcast sky are requested to collect information on the luminance distribution of those skies which are typical for their countries.

(6) When daylight measurements are made in a completed building, the prevailing sky luminance distribution should be measured at the same time, and preferably should be as close as possible to that on which the design of the building was based.

At this meeting a paper on studies in natural lighting of interiors was given by R. G. Hopkinson and his colleagues of the B.R.S. and of the Ministry of Education. The paper describes recent work on daylighting design and quotes the application of the results obtained to a new school and a hospital ward.

Operating Accessories

This report (prepared by the U.S.A.) dealt primarily with the characteristics of the various starting mechanisms and ballasting circuits available for the operation of fluorescent lamps, and pointed out trends in usage. Holders for these lamps were discussed as also was the effect of harmonic currents in overloading cables and transformers. With the wider adoption of fluorescent lighting these harmonic current effects, which can be neglected where only a small part of the load is fluorescent, assume increased importance; the great majority of new installations however still make no special provision for harmonic reduction though it seems probable that this situation will change as the matter becomes more widely known and the implications appreciated.

The report also drew attention to the standards now in process of development or promulgation by the C.E.E. and the C.E.I. The former deal with electrical, thermal and dimensional characteristics primarily from the point of view of safety and security. The C.E.I. recommendations are in the nature of performance specifications for ballasts, transformers and associated devices for radio interference suppression and power factor correction.

Traffic Signals

The secretariat report on traffic signals prepared by the French committee dealt with the study of the British 1951 report, the methods of measurement and statement of the photometric properties of illuminated traffic signals and also of retro-reflecting materials, and the choice of the best specification for the several types of traffic signal. It was thought that iso-candela diagrams should be adopted for the study of the photometric properties of signals. From a discussion on the most suitable frequency for flashing lights such as the yellow warning lights used for pedestrian crossings it appeared that most countries favour a flashing frequency of about 60 flashes per minute with equal light and dark periods.

The report on the colours of signal lights was prepared by the U.S.A. It surveyed the present state of signal-light colour specifications and analysed current problems. It would seem that most of the specifications in use conform in general to the C.I.E. recommendations for signal colours. An appendix to the report contained information on boundary equations used in different specifications, colour temperature of lamps, the transmission values of filters, a bibliography and chromaticity diagrams showing the relationship of the C.I.E. and other typical specification boundaries.

Airborne and Airfield Lighting

The report on airborne lighting and signals dealt with landing lights and instrument lights and the question of exterior lights on rotary-wing aircraft was introduced for the first time. It was agreed that an attempt should be made to draw up a code of recommended practice for aircraft lighting which should go beyond the I.C.A.O. regulations and should include landing lights, instrument lights, interior warning lights, improved signal lights to reduce collision risks, and exterior lights for rotary-wing aircraft.

The report on aviation ground lighting dealt with developments since 1951 when a specialist committee was set

up to prepare a report for the International Civil Aviation Organisation on the characteristics of approach lighting systems. As there are wide differences in the systems used in different countries the preparation of this report was not easy, but a report was submitted to I.C.A.O. and has been incorporated in their International Standards and Recommended Practices. This specialist committee is to continue with its work and will also continue to advise I.C.A.O. A paper on the calculation of approach lights was given by J. Olivier, of France.

Other Subjects

For several years the committee on automobile lighting has been most active and has held a number of intersessional meetings and vehicle headlamp tests. Much of this work has been carried out in conjunction with the International Standards Organisation and concerns vehicle headlamps and pass-lights, rear lights, stop lights and signal lights. Reports have been prepared for I.S.O. and this collaboration between the two organisations is to continue.

A report on floodlights and advertising signs was prepared by Italy. This reviewed current practice on these two subjects in different countries. Work during the next few years will be mainly concerned with luminous sign practice including aesthetics.

Education in lighting was the subject of an interesting meeting. Most countries now seem to be giving some thought to the problems of training lighting engineers and of educating the public on the benefits of good lighting. The extent to which lighting should be included in the training of members of allied professions, e.g., architects, electrical engineers, etc., was discussed; it was thought that it was unlikely, even if desirable, that time could be found to include much lighting in the syllabuses for such professions and that the aim should therefore be to teach these students enough about lighting to enable them to appreciate the work of the trained lighting engineer and to know when to consult him. As regards the lighting engineer himself it was stressed by many speakers that a sound basic engineering training should be given before specialising in lighting. It was apparent that in most countries one of the main obstacles to furthering lighting education was the present limited supply of teachers.

On the education of the public it was thought that electricity supply undertakings in all countries could do more than they do at present. The view was also expressed that properly trained retail sales staff who have direct contact with the public could do a lot to bring about a better appreciation of the benefits of good lighting. In this connection, in a paper on economic and efficiency problems in lighting, R. Aspestrand, of Norway, suggested that the interests of users of light might be better served if the C.I.E. could foster co-operation between manufacturers and consumers by concerning itself with these problems.

Final Plenary Meeting

At the final plenary meeting on the afternoon on June 22 the various recommendations of the technical committees were considered and their work for the next four years agreed upon.

It was also agreed to make some modifications to the method of working of the C.I.E. and to set up working parties on some subjects. The members of these working parties will all be acknowledged experts on that particular subject whose task will be to prepare reports where desirable for publication without the need of waiting until the next meeting of the C.I.E. in four years' time. Subjects for which working parties have not been set up will continue as at present to be dealt with in four-yearly progress reports.

The officers for the next four-year period were also elected at this final meeting. As mentioned earlier in this report Dr. J. W. T. Walsh had been nominated as President at the beginning of the meeting in Zürich. This was now formally put to the meeting and Dr. Walsh was elected unanimously. Vice-presidents for the next four years will be Dr. L. Fink (Austria), Mr. M. Jacob (Belgium), Mr. R. Deaglio (Italy) and Mr. A. Brainerd (U.S.A.).

It is a practice with the C.I.E. for the Central Bureau to be held by different countries from time to time. Since 1948 the administration has been undertaken by the U.S.A. with Mr. C. Atherton acting as Secretary. It has now been agreed that the Central Bureau shall be held by France with Prof. Yves Le Grand as Secretary.

The next meeting of the C.I.E. will be held in Belgium in 1959.

Correspondence

The I.E.S. Code

To the Editor, LIGHT AND LIGHTING.

Dear Sir,—Mr. Bickerdike's letter in your last issue caused me considerable surprise.

His first criticism of the new I.E.S. Code is that it makes the whole subject of illumination [*sic*] seem more complicated than it really is, but it is difficult to understand how this criticism can be made if it is not also applicable to the preceding edition of the Code. Presumably, Mr. Bickerdike feels that Part I of the new code, which attempts to give some idea of why the design of lighting is, in fact, a complicated matter and needs to be done with due observance of the rules which follow if it is to be done well, does not help him either to appreciate that the rules themselves are not merely the arbitrary dictates of pundits or that, figuratively speaking, there is more in the design of lighting than meets the eye. The rules themselves are much as they were previously and, if Mr. Bickerdike's comment is really prompted by Part I, I can only say that this very "potted" exposition of light and sight has received emphatic commendation from another of Mr. Bickerdike's profession.

More surprising is Mr. Bickerdike's doubt whether the Code is intended for architects and his reference to the omission of architecture from the Code as a serious neglect. The fact is that Part III of the Code, which principally concerns architects, was written by an architect for architects!

True co-operation between architect and lighting engineers is not yet possible, says Mr. Bickerdike, firstly, because the lighting engineer seldom appreciates architectural objectives. I do not know whether or not this is so but, if lighting engineers lack this understanding, is not the co-operation of the architect the very way—indeed the only way—by which they can be led to it? Surely architectural objectives are not indescribable even when they are peculiar to particular buildings, although unless they can be, and are, communicated to the lighting engineer should he be expected to appreciate them? If, however, as Mr. Bickerdike implies, the approach of modern architects to design involves some general objectives as to lighting which are not explained at all or are not sufficiently explicit in the Code, this is a defect we will be only too glad to remedy at the earliest opportunity if architects will tell us what should be said.

Finally, although the preface states that recommendations in the Code have a scientific basis, it does not suggest that architects or any other busy people should, or need, plough through pedantic literature. If anyone wishes to expand his knowledge by doing so, or to examine the credentials for certain recommendations, Appendix II suggests some fields he might plough.—Yours, etc.,

H. C. WESTON,

Orpington. *Chairman, I.E.S. Code Committee.*

The passenger-handling building, seen from the aircraft stand.

New terminal buildings at

London Airport

Architect, Frederick Gibberd, C.B.E., F.R.I.B.A., M.T.P.I.; architect's partner in charge, R. J. Double, A.R.I.B.A.; responsibility for construction, Director-General of Works, Air Ministry; consulting engineers, Sir William Halcrow & Partners; heating and ventilating consultants, G. H. Buckle & Partners; electrical consultants, Ewbank & Partners.

London Airport, the main base of B.E.A. and B.O.A.C., was opened to civil aviation on January 1, 1946. Covering an area of nearly 3,000 acres, south of the Bath Road, it is used by 23 international airlines, and handles each year 1,000,000 passengers, and 2,000 tons of freight.

The recently completed terminal buildings at London Airport—the control building and the passenger-handling building—form part of the first stage of the great terminal complex designed by Frederick Gibberd to replace the temporary prefabricated buildings which have now been outgrown. Due for completion early next year is the eastern apex building, which will link the passenger-handling building now completed with another similar building which is to form part of a later scheme.

The Passenger-Handling Building

The most important areas of the passenger-handling building are situated on the first floor, which is reached via escalators from the ground floor reception area, and via ramps from the aircraft stand. This floor of the building is divided into a series of parallel sections, comprising respectively the main concourse, the customs' hall, the immigration hall, the health authorities, the airside waiting-room, and the airside gallery, where passengers await their aircraft. Along the main concourse are information bureaux, shops, post and cable offices, and a buffet.

Ten passenger-handling channels cut across these various sections, from the " land side " to the " air side " of the building. Each channel is reversible and is, therefore, capable of handling inward- or outward-bound passengers.

On the ground floor of the building, in addition to the reception area, there is the baggage-handling section, accommodation for technical staff, and stores for technical equipment.

On the second floor there is office accommodation for the operating companies, a restaurant (with lounge bars overlooking the airfield), roof gardens for the general public, more shops, hairdressing saloons, and cloakrooms.

Placed centrally at first floor level is a self-contained suite for transit or "inter-line" passengers who have to remain on the air-side of the customs while waiting to continue their journeys. It contains a buffet-lounge, restaurant, shops, cabling facilities, and a small nursery.

The Eastern Apex Building

The eastern apex building will, when completed, provide facilities for the handling of aircraft operations, accommodation for off-duty crews, and various amenities for the general public, including a post office, a news cinema, and an exhibition hall. Cantilevered over the airfield will be a restaurant, with a small dance floor, a grill room, and several private suites.

Construction

The main parts of both completed buildings are steel-framed, the structural steelwork being encased in concrete. The main structural grid is 12 ft., with beam spans in multiples of 12, 18, and 24 ft. External walls are of 11-in. cavity brickwork, faced in some areas with slabs of artificial stone. There are complete window walls—aluminium framed—to the main concourse and to the airside gallery.

Floors and roofs are mostly of precast concrete units, finished with a variety of materials, including concrete tiles, brick and York stone paving.

The structure of the customs' hall is of welded steel Portal frames; the roofing comprising woodwool slabs, a lightweight screed, and a covering of 3-ply bituminous felt, surfaced with marble chippings. Woodwool roofing is also used in the airside gallery and in the bridges which give access to the ramps leading to the aircraft stand.

Floor finishes include Derby Dean limestone in the concourse, terrazzo on the ground floor, rubber in the immigration hall, and cork tiles in the airside waiting rooms.

Apart from the areas where woodwool roofing has been used there are suspended ceilings throughout—mostly of the acoustic type—to provide space for the wide variety of services.

One central heating plant serves both completed buildings and will also serve the eastern apex building. An oil-fired boiler provides, via a heat exchanger, high pressure hot water for underfloor heating in the main concourse and the customs' hall, for ceiling heating in the restaurants and lounges, and for radiators in the offices.

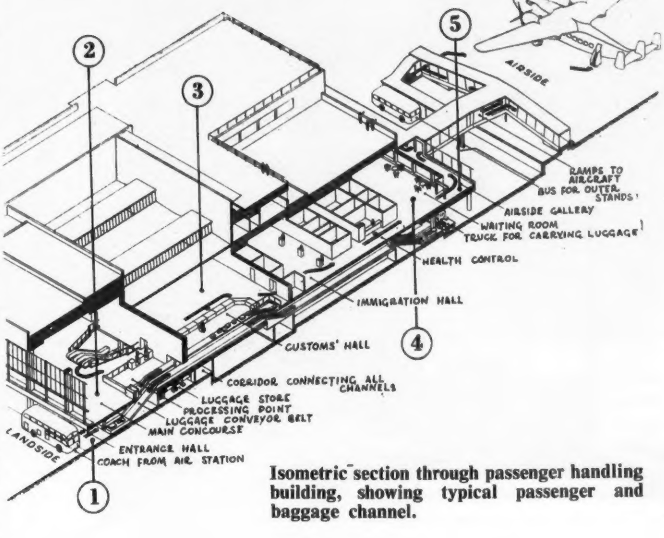
Ventilation plant provides for six air changes per hour in all public rooms.

The Lighting

Lighting intensities in the passenger handling building have been carefully arranged so that passengers arriving or departing at night are not dazzled by high intensities when they first enter the building. Similarly, passengers *departing* at night are gradually accustomed to the darkness of the airfield by passing through parts of the building where lighting intensities are low.

In certain parts of the building, particularly the customs' hall, fairly high lighting intensities are required, but, whether they are arriving or departing, passengers do not reach these parts of the building until they have passed through comparatively dimly lit areas.

In the ground floor entrance halls the illumination level is very low; in the main concourse it is around 5 lm/ft². In the customs' hall it goes up to about 15 lm/ft² (30-35 lm/ft² on the actual benches). In the immigration hall it is slightly lower—12 lm/ft²; in the airside waiting-room it drops to 5 lm/ft² again; and in the airside gallery it is only 2 lm/ft², so that passengers can see out and watch the planes take off and land.

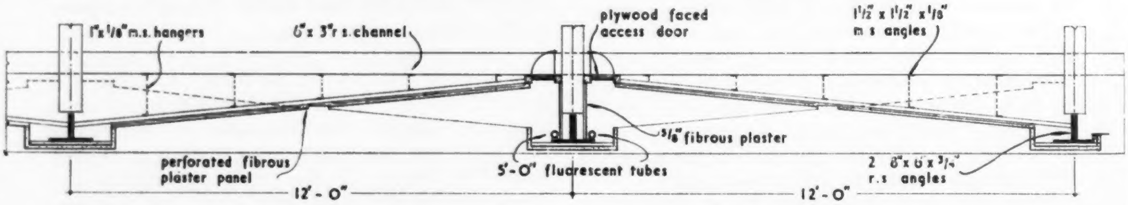


Isometric section through passenger handling building, showing typical passenger and baggage channel.

1 **Ground floor entrance hall: typical view looking towards escalators and patterned tile-faced wall. Note the dramatic contrast between the dimly lit entrance hall, with its low ceiling, and the comparative flood of light coming from the main concourse on the first floor.**

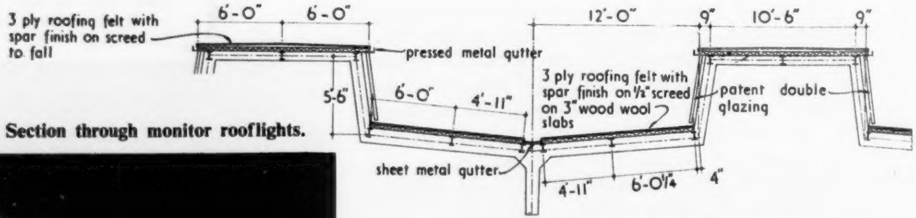
2

Section through concourse ceiling.



The main concourse: daylighting by large floor-to-ceiling windows, facing N.E. The chequer-pattern acoustic ceiling, undulating in two directions, is lit by concealed fluorescent lamps, giving illumination level of approximately 5 lm/ft². Access to the lamps is from above. Additional lighting is provided by contemporary-styled chandeliers, designed by the architect, as seen in foreground of photograph, while spotlights in ceiling, near windows, minimise reflections. Centre section of concourse, where buffet, shops, etc., are situated has different treatment—flush ceiling, with circular tungsten fittings recessed into it.

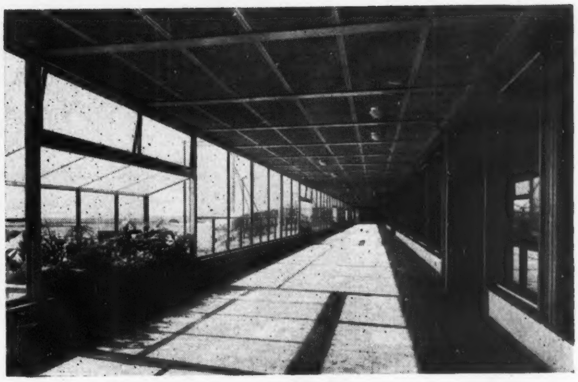
Section through monitor rooflights.



3

The customs' hall: glare-free top lighting, provided by monitor-type rooflights, gives high degree of illumination along the inspection benches. The rooflights are glazed with patent double-glazing units, to increase thermal and sound insulation. Special fluorescent fittings, designed by the architect on the basis of an idea developed by B.R.S., are placed along both edges of each monitor, so as to provide artificial illumination to simulate the natural lighting. There are 240 of these fittings, each comprising two 80-watt white lamps, with 'Perspex' side panels and transverse metal louvres.

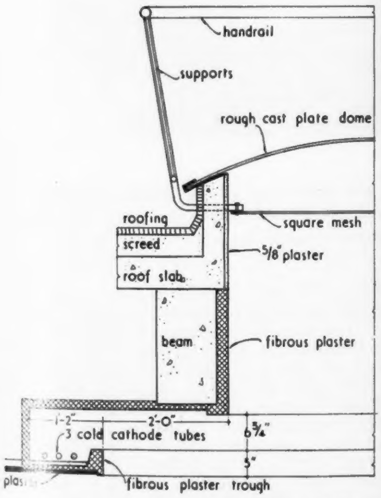
4 The airside waiting room: lit mainly by wall bracket fittings (see illustration on page 314). Small tungsten fittings recessed into ceiling near windows prevent reflections. The wallpaper on the end wall was designed by the architect. Beyond the window wall is the airside gallery.



5 The airside gallery: this gallery runs the full length of the building, giving access to the three bridges and ramps that lead down to the aircraft stands. Simple ceiling fittings provide minimum lighting, so that passengers can see out. The cantilevered window box on the left is one of twelve.

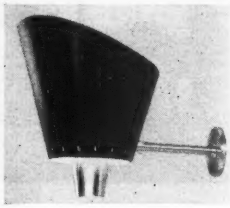
MAIN STAIRCASE TO BALCONY LOUNGE

The main staircase and the surrounding columns are faced with Genoa green marble; treads of the staircase are white Sicilian; risers black terrazzo. The ceiling over the staircase is pierced by 16 dome lights which, at night, are lit by concealed cold cathode tubes, giving an "inverted saucer" effect. The roof above is laid out as a roof garden, and the dome lights are, therefore, protected by circular balustrades. A tray of wire mesh under each dome protects people below from broken glass, should any of the lights get broken. Access to the cold cathode lamps is from above, via flush-fitting trap doors in the fibrous plaster surrounds.



Section through dome light.

THE SECOND-FLOOR LOUNGE AND BAR



The second-floor buffet-lounge and bar: semi-recessed tungsten fittings in acoustic ceiling; wall brackets on columns; recessed fittings in underside of bar canopy. The wall brackets (see photograph, above right) comprise a stove-enamelled reflector, which throws light down, as well as up, and a satin brass lampholder. The bracket and wall plate are also of satin brass.

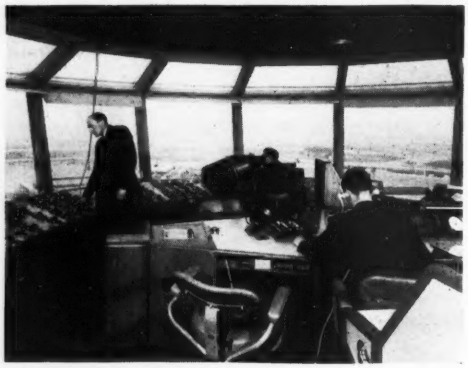
THE CONTROL BUILDING

The control building consists of a T-shaped two-storey block, from the apex of which rises a 122-ft. 6-in. tower. A central vertical core, extending the full height of the building, contains lifts, ventilation trunking, a pneumatic tube for messages, cable ducts, and other services.

Suspended ceilings have been used throughout; the space between these and the structural floors housing the horizontal runs of the various services. The control room at the summit of the tower is fully air conditioned.

For the windows of the control room special blue-tinted " anti-sun " glass has been used, mainly to reduce the solar transmission of heat, partly to cut down glare. The windows are double glazed, with heating cables between the two sheets of glass to prevent condensation.

There is very little artificial light in this room, as this would make it difficult for the men working there to see out at night. Most of the illumination comes from the various instruments—the radar screen, for instance.



Left, part of the east wing of the control building, and the control tower, seen from the east. Above, the interior of the control room.

The general contractors were Taylor Woodrow, Ltd., for the building work, and Redpath Brown and Co., Ltd., for the steelwork. The electrical installation was carried out by Electrical Installations, Ltd. Dome lights were supplied by T. and W. Ide, Ltd.; anti-sun glass in the control room by Pilkington Bros., Ltd. Lighting fittings are by Courtney Pope (Electrical), Ltd. (standard recessed fluorescent fittings); Thorn Electrical Industries, Ltd. (wall brackets in second floor restaurant and air-side waiting-rooms); Ekco-Ensign Electric, Ltd. (special fluorescent fittings in customs' hall); A. Arden and Co., Ltd. (" chandeliers " in main concourse); Falk, Stadelmann and Co. Ltd. (large wall bracket fittings in main concourse, and fittings on roof garden).

The Indirect Component of Illumination in Artificially-lit Interiors

Calculation by B.R.S. "Split Flux" method.

By R. G. HOPKINSON, Ph.D., M.I.E.E., F.I.E.S.*

It may sometimes be of value to know the magnitudes of the direct and indirect illuminations in a room. This is particularly the case when shadowing and modelling are being studied, or when one needs to know the luminances of the surfaces of the room.

There are several methods available for obtaining this information, each of which has its special application. This note is to draw attention to the use of a modification of the "Empirical Daylight Formula" described by the author and his colleagues (Trans. Illum. Eng. Soc. (London) **19,** 201-219, (1954)) for the calculation of the indirect component in artificially lit interiors.

The basis of this formula is to split the total flux into two components, one of which is reflected first from the upper parts of the walls and the ceiling, the other which is reflected first from the lower parts of the walls, and the floor. The Indirect Illumination at any part of the room is then found by:—

$$\text{Indirect Illumination} = \frac{\text{Total first reflected flux}}{A(1-R)} \quad \text{lm/ft}^2$$

where A is the total area in sq. ft. of all the surfaces in the room

R is the average reflection factor of these surfaces.

This formula, although based on the theory of the integrating sphere, and not that of inter-reflections inside a rectangular parallelepiped, appears to give values of the indirect illumination in simple room shapes which are in accord with values based on more complex methods. In particular, the values agree with those given in the Brightness Calculation Tables of the American Illuminating Engineering Society's Handbook (I.E.S. New York, 1952) in cases where direct comparison can be made. These tables are, of course, based on the Moon and Spencer inter-reflection formulae. Cross-checks with measurements in rooms have not yet been made, so it has not been checked how accurately these American tables agree with measurement.

A typical calculation is as follows:—

To find the ceiling luminance in a room 25 x 20 x 10 ft. lit entirely by nine direct luminaires, each lamped with a 200-watt filament lamp mounted 8 ft. above the floor.

Ceiling reflection factor .... = 80 per cent.

Wall reflection factor .... = 50 per cent. (assume window blind also 50 per cent.)

Floor reflection factor .... = 10 per cent.

Average reflection factor of room $= \dfrac{(25 \times 20)(80 + 10) + 2(25 + 20) 50}{2[(25 \times 20) + (25 \times 10) + (20 \times 10)]}$ = 47.5 per cent.

Average reflection factor of room below line of fittings .... = 24.0 per cent.

First reflected flux = flux emitted above line of fittings × reflection factor of upper walls and ceiling
+ flux emitted below line of fittings × reflection factor of lower walls and floor.

In this case all flux is emitted below the fittings, so the first component in the formula is zero.

First reflected flux therefore $= O + F \times 24$ per cent. where F is the total emitted flux.

The Indirect Component will then be

$$I = \frac{\text{1st reflected flux}}{A(1 - R)}$$

(A = 1,900 sq. ft., R = 47.5 per cent.)

$$= \frac{0.24\ F}{1{,}900(1 - 0.475)}$$

$$= 2.4F \times 10^{-4}\ \text{lm/ft}^2$$

9 × 200-watt lamps give a total flux of 9 × 2,725 lumens, and if an efficiency of the fitting of 70 per cent. is assumed, as in the Harrison-Anderson tables.

$$F = 9 \times 2{,}725 \times 0.7 \text{ lumens}$$

$$I = 2.4 \times 9 \times 2{,}725 \times 0.7 \times 10^{-4}\ \text{lm/ft}^2$$

$$= 3.04\ \text{lm/ft}^2$$

Luminance of ceiling .... = 3.04 × 80 per cent. = **2.43** ft.-lamberts.

Comparison can be made with the I.E.S. Handbook values as follows (the full calculation is not shown):—

Total Illum. on working plane (calculated by the Harrison-Anderson method) = 26 lm/ft²

Room coefficient (see Table 9-7 in I.E.S. Handbook) = 0.45

Luminance of ceiling (via Table 9.8) = 0.115 × 26 = **3.0** ft.-lamberts.

The maximum discrepancy between the values obtained from the I.E.S. Handbook for the luminances of room surfaces, and those obtained by the use of the present formula are of the order of ± 20 per cent. The Handbook tables do not give, as does the formula, the amount of indirect light in the room.

Comparison with values of illumination on the working plane from totally indirect illumination obtained (a) by means of the formula and (b) by means of the Harrison-Anderson empirical "lumen method" show close agreement. For example, for the same room dimensions and 9 × 200-watt totally indirect luminaires, but with a reflection factor of 80 per cent. for the ceiling and upper walls above the fittings, 30 per cent. for the rest of the walls and 10 per cent. for the floor, the indirect (and here the total) illumination is given as **13.5** lm/ft² by the formula and **13.8** lm/ft² by the "Lumen" method.

The formula may, therefore, give for some purposes a sufficiently close estimate of the indirect illumination in an installation. It may save some labour in the calculations for mixed installations, say, of direct and indirect fittings (e.g. down-lights and diffusers). In other cases the desired information may be obtained more easily by other means. The method is put forward as a possible alternative tool to be at the disposal of the lighting engineer.

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* D.S.I.R. Building Research Station, Garston, Watford, Herts.

Light and Plant Growth

The annual Masters Memorial Lecture of the Royal Horticultural Society was given this year by Prof. R. H. Stoughton, D.Sc., Professor of Horticulture in the University of Reading. Prof. Stoughton, who was recently awarded the Victoria Medal of Honour of the R.H.S., is the only professor of horticulture in this country and he chose as the theme of his lecture the effect of light on plant growth and development, a subject on which a considerable amount of research has been carried out at Reading.

The first portion of the lecture was concerned almost entirely with the physics of radiation, with particular reference to the visible, the ulra-violet and the infra-red which, said the lecturer, were the only parts of the electromagnetic spectrum vitally important in biological processes. The spectral distribution of the light from various sources, and the methods by which light could be measured were described. Since the sensitivity curve of a plant is very different from that of the eye, a measurement of illumination is, by itself, of little value unless the spectral distribution of the light is known. It has been proposed to use in horticulture a method of describing the spectral distribution which is exactly analogous to the wave-band method proposed for specifying the colour rendering properties of fluorescent lamps, but the number of bands in this case is four instead of eight and the wave-length limits are 10,000, 7,200, 6,100, 5,000, 4,000 Angstrom units.

Light affects not only plant growth but also seed germination and the induction of flowering. With regard to seed germination the effects are complex; in some cases light assists germination, in others it has an inhibitory effect. On plant growth the effect is great. The lecturer distinguished between what he called "elongation growth" with, usually, a spindly habit and a general increase in the size of the plant with a normal growth habit. Elongation growth is checked when the plant receives the light it needs for photo synthesis, but the total growth rate is increased by light, a maximum rate being attained, usually, at an illumination of some 50 to 70 per cent. of full daylight.

In the second part of the lecture, Prof. Stoughton dealt first with photo-synthesis, describing this as the fundamental process on which all life on earth was, in the last resort, dependent. It was, he said, the only process in which a compound of high energy was built up from one of lower energy. With the aid of light the living protoplasm in the plant was able to use carbon dioxide and water to form a carbohydrate, typically a sugar. Looking into the future, the lecturer said he felt sure that, sooner or later, this process would be imitated without the intervention of the plant and then all our food problems would be completely solved.

The process takes place in two stages. First, under the action of light, the water is split up and part of it combines with a substance called a hydrogen-acceptor which is thus reduced, with the liberation of oxygen. The second process is independent of light; the reduced hydrogen-acceptor combines with carbon dioxide to form a simple carbohydrate and this is then built up into a sugar. The effectiveness of light of different wave-lengths in promoting photo-synthesis is curiously uncertain. Red light is the most effective and green the least (as it is least absorbed), but whether blue is more or less effective than green has not been settled.

The next subject dealt with was the effect of light on plant development, and here the lecturer drew a definite distinction between development and growth, the latter term being restricted to elongation or to increase in the weight of the plant. He defined development as a qualitative change leading to the ability of the plant to reproduce itself, or, in other words, the development of "ripeness to flower." This change is affected by a number of factors, the principal ones being temperature, light, nutrition, water supply and the functioning of the hormone mechanism in the plant. In the promotion of development the important factor as regards the effect of light is its duration, not its intensity, whereas for growth, intensity is the important matter. The effect of the relative duration of light and darkness is known as photo-periodism. Some plants are "long day" plants which require a certain minimum duration of light to be exceeded before they can develop ripeness to flower; others are "short day" plants which require at least a certain minimum period of darkness every 24 hours; yet other plants, such as the carnation, seem to be indifferent to day length.

Prof Stoughton then described experiments on the effect of light of different wave-lengths on flowering when this light was used to interrupt the normal dark period. He said that red was again the most effective, while green and blue produced relatively little result.

Turning to the applications of this work in practical horticulture, the lecturer said that it was only comparatively recently that suitable light sources had become available to provide the high illumination required for photo-synthesis at a reasonable cost. These sources were the various gas-discharge tubes, especially the HPMV lamp and the fluorescent lamp, though the xenon lamp might well become important in the near future. At the seedling stage light can be applied economically because large numbers of plants can be assembled in a comparatively small area. The light gives better growth in readiness for planting out and the process is especially valuable with tomatoes and with cucumbers. The control of the flowering period of certain plants is a much more economical process because a comparatively low illumination is quite effective, and Prof. Stoughton showed an installation of tungsten filament lamps used to retard the flowering period of chrysanthemums.

Glancing at the future, the lecturer said that there were two outstanding subjects for research. One was the relative effectiveness of light of different wave-lengths in producing plant growth and development; the other was the synthesis of the flower-forming hormone in plants.

The lecture will be published in full in the Journal of the Royal Horticultural Society.

I.E.S. Transactions

Arrangements have been made with a firm of bookbinders for members of the I.E.S. and subscribers to have their copies of the Transactions bound in uniform style. The binding is in dark green cloth with the title, volume number and year in gold on the spine.

As the I.E.S. Transactions contain valuable works of reference many will no doubt wish to preserve their copies this way, particularly as the cost (8s. 6d. including return postage) is so low. The binding is of excellent quality and has been approved by the General Purposes Committee of the I.E.S.

Those wishing to have their copies bound, one year per volume, should send them direct to the binders (*not* to the I.E.S.) together with the index and cheque or postal order for 8s. 6d. per volume. The address is: P. G. Chapman and Co., Ltd., Kent House Lane, Beckenham, Kent. (If an index is not enclosed this should be mentioned.)

A limited supply of copies of the Index for the 1954 volume is available from the I.E.S. for those who have mislaid the index which was included as a loose sheet in issue No. 10, 1954. A limited number of copies of individual issues (price 1s. 6d. to I.E.S. members, 5s. to non-members) are also available to make up complete volumes.

Spring-back binders to hold copies temporarily during the year of issue and before permanent binding are available from the I.E.S., price 6s. 6d.

Lighting Abstracts

OPTICS AND PHOTOMETRY

193. General guide to photometry 535.24

Illum Engng., **50,** 201-210 (*April*, 1955).

Gives two further sections of the I.E.S. Guide dealing with methods of measurement and standards, other sections having been reproduced in the March, 1955 issue. The first of the present sections is concerned with the measurement of illumination, luminous intensity, luminous flux, photometric brightness and beam candlepower, this last sub-section being treated in some detail. The other section is concerned with primary, secondary and working standards of luminous intensity. P. P.

612.843.3

194. Special difficulties of research into the quantitative determination of visual performance.

H. Konig, *Bull. Assoc. Suisse Elect.*, **46,** 487-488 (*May* 14, 1955). *In German.*

Gives some examples of the anomalies met with in making visual measurements. The first is the non-additivity of lights having saturated colours and the author points out that differences of 10 per cent. in such matters as street lighting have no significance. Other examples concern the assessment by different observers of the relative merits of automobile headlight beams when an attempt is made to form a synthesis of a number of different factors; the need for a convention in such cases is explained. The last example is the effect of colour in assessing the desirable level of illumination in a room; a higher illumination by daylight than by tungsten light is demanded. J. W. T. W.

612.84

195. Influence of physiological optics on lighting.

W. Sinn, *Lichttechnik*, **7,** 182-184 (*May*, 1955). *In German.*

This is a general discussion of the importance of various phenomena, well-known in physiological optics, which have a marked influence on lighting design. In street lighting, for example, the glare from a source is proportional to the product of area and luminance, so that size *per se* is unimportant. Flicker is less noticeable at high values of general illumination. Time is needed for adaptation in passing from an area of high illumination to one at a lower level.

J. W. T. W.

LAMPS AND FITTINGS

196. Measured utilization factors II. 621.329

W. M. Potter and A. H. Russell. *Illum. Engng.*, **50,** 177-193 (*April*, 1955).

A continuation of an earlier study in which measurements of utilisation factor of various types of incandescent and fluorescent luminaires were made in a 12½-ft. square laboratory test room. In the present study a test room 30-ft. square was used, so enabling rooms large in proportion to their height to be studied while avoiding undue distortion of the room scale. Very considerable information is given on the measurements which have been made in this larger room, including the effect of suspension height on utilisation and the determination of the direct and upward components of flux from extended (fluorescent) sources. Special attention is given to the trapping of ceiling-reflected light by the luminaire and to the reduction in horizontal illumination caused by the shadowing effect of a person. P. P.

197. Luminous flux from a luminaire. 621.329

W. A. Hedrich, *Illum, Engng.*, **50,** 170-172 (*April*, 1955).

The conventional zonal-flux method of computing lumen output requires a knowledge of the constants relating to each of the equal angular increments into which the polar distribution curve is divided, and necessitates the summation of a series of products of these constants and the directional luminous intensities. The method proposed involves little more than the summation of a number of directional luminous intensities. The theory of the method is the same as that of the Rousseau Diagram, the area of the diagram virtually being found by a mean ordinate method. P. P.

621.326

198. Most efficient form for the filament in a projector lamp.

H. G. Fruhling and H. Hoppmann, *Lichttechnik*, **7,** 121-123 (*April*, 1955). *In German.*

In an earlier paper (*Lichttechnik*, **5,** 264, *Aug.*, 1953) J. Rieck discussed the most efficient arrangement of the filament in a projector lamp used for projecting cinema film, selecting the 250-watt 220-volt lamp as an example. In the present paper the modifications he suggested are discussed from the lamp maker's point of view. The authors point out that such modifications may well lower the overall efficiency of the lamp to a greater extent than the gain due to an optically better filament form. This is confirmed by experimental measurements with four projectors, using (a) the normal type of projector filament and (b) a special type designed to fill the objective more efficiently. The latter arrangement was less efficient than the former by various amounts up to 10 per cent. J. W. T. W.

LIGHTING

199. Lighting in churches. 628.972

K. Hallgren, *Ljuskultur*, **27,** 29-35 (*April-June*, 1955). *In Swedish.*

The design of electric lighting in older churches must take into account the already existing environment. The lighting of new churches is an entirely different problem, in which there are opportunities from the beginning to link the architectural and lighting designs. Some examples are given of both techniques in a series of 13 photographs.

R. G. H.

200. Where are we in public lighting? 628.971.6

L. Gaymard, *Bull. Soc. Franc. Elect.*, 7th Ser., **5,** 142-156 (*March*, 1955). *In French.*

Present street lighting practice on the Continent is reviewed. Sodium lamps and uncorrected mercury lamps are little used on account of the colour distortion. A strong case is made for tubular fluorescent lamps, which have recently been improved in life, reliability and lumen maintenance and it is described as by far the best light source for public lighting and the most economical. New corrected high-pressure mercury vapour lamps have the advantage of smaller and neater equipment and form a serious competitor to the tubular type. Criticism of tubular fluorescent equipment on aesthetic grounds has been met by various devices, of mounting the lamps vertically, on short columns, in Italy (the author considers the mounting height used in England of about 25 ft. to be too great for this

type); nevertheless there is some trouble with glare at the lower mounting heights. Mounting of equipment on façades as at Aberdeen or Harlow is another solution. Several installations in Italy and France have used horizontal lanterns with the axis parallel with the street, at short spacing. On several bridges, notably at Namur and Dinant in Belgium, lighting from parapets has been successfully achieved. The Americans, who first used this method, recommended that it should not be used when the width between parapets exceeded 30 ft., but the Namur bridge exceeds 50 ft. in width. J. M. W.

201. Cavity efficiency for translucent ceilings. 628.93

R. T. JEAVONS, R. H. HORNER AND R. D. BURNHAM, *Illum. Engng.*, **50,** 137-140 (*March,* 1955).

The efficiency of the cavity above a translucent ceiling is dependent on room size, cavity depth, cavity reflection factor and distance of lamps from the light diffuser. This efficiency can be calculated by theoretical equations. The present paper describes measurements made on a model ceiling with a cavity of adjustable size to determine the accuracy of these equations and to solve the problems of relatively deep cavities and of using reflectors above the lamps. P. P.

202. Lighting calculation methods. 628.93

W. JAEDICKE, *Lichttechnik*, **7,** 84-88 (*March*) and 128-131 (*April,* 1955). *In German.*

In the first part of the paper the author describes the various methods used for calculating direct illumination from a source which can be regarded as a point, from line sources (with special reference to fluorescent lamps) and from surface sources. The distribution of illumination over the floor of a large hall lit by various arrangements of light sources is shown by means of perspective drawings of the illumination solid in which the height above the floor at any point is proportional to the illumination at that point. The second part of the paper deals with the lument method of calculation and the use of inter-reflection tables. J. W. T. W.

203. Natural lighting of school classrooms. 628.92

G. FESEL, *Lichttechnik*, **7,** 123-131 (*April,* 1955). *In German.*

The author has carried out an extensive series of measurements of daylight factors in model classrooms under an artificial sky having the Moon-Spencer luminance distribution. The models were of actual classrooms designed by different architects. Different types of fenestration were examined, viz., windows on one side only (two heights), windows on one side with clerestory windows (five kinds) on the opposite side, and windows on one side with clerestory windows (in the roof) having the same aspect as the side windows. The results are given in the form of a number of daylight factor diagrams. In one case the light from the clerestory passed through a louvred ceiling. J. W. T. W.

628.971.6

204. Experimental street lighting installations.

H. WUGER, *Bull. Assoc. Suisse Elect.*, **46,** 485-486 (*May* 14, 1955). *In German.*

After a table showing the mileage of different classes of road in the Zurich canton the author describes an experimental installation consisting of two stretches of roadway, each 11 spans long and each equipped with three systems of lighting. Both have sodium and fluorescent, the third system being tungsten in one case and colour-corrected mercury in the other. The lumen output is approximately the same for each system. No conclusions are given. An important factor is the performance under foggy conditions —prevalent in the neighbourhood of Zurich. J. W. T. W.

628.971.6

205. German recommendations for street lighting.

E. VON DER TRAPPEN, *Bull. Assoc. Suisse Elect.*, **46,** 461-466 (*May* 14, 1955). *In German.*

In Germany, as in England, street lighting is under the control of the local authority. Recommendations for good street lighting have recently been drawn up and these are discussed in turn in the paper. Figures of horizontal illumination are stated, depending on traffic density; then come sections dealing with evenness of illumination and with glare. The arrangement of the sources occupies a long section in which junctions and crossings, open spaces, bridges, underpasses and tunnels, and bridges over railways are treated individually. Some illustrations of novel installations with fluorescent lamps are given. Maintenance and the aesthetic aspect of street lighting are dealt with rather briefly.

J. W. T. W.

628.971.6

206. Lighting of traffic routes in the Netherlands: past experience and future prospects.

N. A. HALBERTSMA, *Bull. Assoc. Suisse Elect.*, **46,** 457-461 (*May* 14, 1955). *In German.*

An account of the development of traffic route lighting in Holland from the introduction of the sodium lamp in 1932. The various features (mounting height, spacing, luminous flux emitted) are discussed seriatim and the gradual improvement is noted. The use of fluorescent lamps is increasing. Photographs are given of an installation with continuous lines of fluorescent lamps suspended across the carriageway at 250-ft spacing, each line having 11 lamps. Both wet and dry conditions are shown. Research on the problems of street lighting, at present in progress in different countries, is mentioned and the paper concludes with a section on luminance measurements and their interpretation.

J. W. T. W.

628.971.6

207. Legal control of public lighting in Switzerland.

A. SCHELLENGERG, *Bull. Assoc. Suisse Elect.*, **46,** 466-469 (*May* 14, 1955). *In German.*

A general account of the complicated legal position with regard to street lighting, in which the relative functions and powers of the Confederation, the cantons and the municipalities are explained. Certain cantons have statutory regulations for the street lighting within their boundaries The desirability of national control of the lighting of through traffic routes connecting main towns is discussed.

J. W. T. W.

628.971.6

208. Public lighting: construction, operation and maintenance.

P. F. ROLLARD, *Bull. Assoc. Suisse Elect.*, **46,** 469-473 (*May* 14, 1955). *In French.*

Types of current distribution are described, with particular reference to methods of control. In the canton of Geneva a village has been wired with five-core cable, a small core being incorporated especially for the street lighting. In towns the lanterns may be suspended from overhead cables and the supply is then carried similarly. Alternatively wall-mounting may be used but this is found to have certain disadvantages. In suburban areas columns have to be employed. The desiderata for a street lighting lantern are listed and totally enclosed fittings are condemned. Methods of control are treated at some length. After trials of different systems, Geneva employs manual control, operated on receipt of a warning signal given by a photo-electric cell. There is a section of the paper dealing with comparative costs and leading to the conclusion that sodium lighting is the most economical. J. W. T. W.

Notes on the City and Guilds Examination Papers

(2) Final Grade, First Paper

By S. S. BEGGS, M.A., F.I.E.S.*

Introduction

In the Intermediate Grade examination, the student is expected to show a good understanding of the *basic principles* of lighting technology. In the Final Grade examination he is expected to show ability in the *application* of these principles to everyday practice.

It may be noticed that sometimes very similar questions appear in both the Intermediate and the Final Grade papers. This does not mean that the two examinations are of the same standard nor that the same answer will do for both; the answer required in the Intermediate Grade examination should relate to the fundamental idea involved, whereas the answer in the Final Grade examination should refer to practical application in as much detail as the time available allows. The student will clearly be greatly helped if he knows of installations, fittings or procedures already in use, but it should be noted well by the candidate that the mere description of some such in answer to a question in the examination paper will not get many marks if the reason for the adoption of the particular arrangement described is not brought out. Sketches should be included, whenever helpful, but they should show clearly whatever they are intended to portray; very rough scribbles are not good enough.

There is no one standard textbook for the Final Grade examination, although there are several that have been written as a result of courses in lighting in schools of electrical engineering. The City and Guilds Institute publishes a list of books which may be helpful. Two of the most useful are " Principles of Lighting " by W. R. Stevens, and "Photometry " by J. W. T. Walsh (both published by Constable). In the following articles on the three Final Grade papers, where the answer involves more or less standard data available in the published books, such will not be given in full, but the reader will be referred to the books.

The complete Final Grade examination consists of three papers, of which the first is compulsory for all candidates for this examination, whilst the second and third papers are alternative choices. The first paper relates to light sources and a study of the visual task, with which all concerned with the technical side of lighting need to be familiar. The second paper relates to radiation, photometry and vision and is intended for those specialising in laboratory measurement or testing, whilst the third paper relates to lighting practice and fittings design and is appropriate to the application side of lighting. A candidate may take all three papers if he wishes, but this is not expected normally; the Intermediate Grade covers the basic principles of both sides, and the illuminating engineer will not usually require a knowledge of the whole of the wide subject to the advanced level of the Final Grade examination, although he will certainly find the wider background helpful if he can attain it.

FIRST PAPER

(1) *Describe, with sketches, the construction and operation of a 125-watt high-pressure mercury-vapour fluorescent discharge lamp, showing also a circuit diagram for operation on a 240-volt 50 c/s. a.c. supply. What are the advantages and disadvantages of this type of lamp compared with the non-fluorescent type? Comment on the degree of colour correction which it provides.*

The 125-watt H.P.M.V. fluorescent lamp and its associated circuit are basically similar to all the H.P.M.V. types, and will not be described in detail here. The main features to be shown are (1) the small inner tube of quartz, (2) the two main activated electrodes, with the third auxiliary electrode to start the discharge, (3) the high resistance in series with the auxiliary electrode, to prevent any significant current short-circuiting the main discharge in use, (4) the glass bulb of general service shape with coating on its inner surface of fluorescent powder responsive to long-wave U.V. radiation, (5) the G.E.S. or 3-pin bayonet cap and (6) the mercury vapour and rare gas filling of the inner tube. The normal circuit incorporates a choke coil in the phase lead to the lamp, and a capacitor in parallel with the lamp and choke, to improve the power factor of this combination. (*Note*: A sketch of the lamp construction and a diagram of the circuit should be given; the function of each part should be mentioned briefly, and also the change in the character of the discharge in the first few minutes after switching on.)

The main advantage of the fluorescent H.P.M.V. lamp over the non-fluorescent type is the much better colour rendering of the light it gives. The spectrum is largely continuous, from the fluorescent powder, although a considerable amount of the line radiation from the discharge filters through; the proportion of long wave-length " red " light is increased some five or six times (to about half that in natural daylight) so that colours and complexions appear more normal. The bulb is heavily diffusing, which is an advantage when it is visible, e.g., in open industrial fittings, but a disadvantage if an appreciable degree of concentration of the light is required, e.g., in some street lighting. In general the only disadvantage of the fluorescent lamp compared with the non-fluorescent type is its higher cost of manufacture.

(2) *Explain the following terms: luminous flux, relative luminous efficiency (relative luminosity factor); luminance, luminous intensity; luminosity.*

(*Note*: A *definition* alone is not sufficient, since the question asks for an *explanation* of the terms. A much greater knowledge is expected here than if this question appeared in the Intermediate Grade examination.)

(a) Light is a form of radiant energy, and its measure is therefore that of a rate of flow of energy, viz., power. The

* Research Laboratories of The General Electric Co., Ltd.
Part (1) of this series appeared in the July issue.

eye does not respond equally to the same power at all wave-lengths; the power, therefore, must be weighted according to the relative sensitivity of the eye at each wave-length (see section (b) below) in order to be a measure of light. *Luminous flux* is radiant power weighted in this way.

(b) *Relative luminous efficiency* is the measure of the sensitivity of the eye under the same conditions to light of different wave-lengths, that for the wave-length of maximum sensitivity being taken as unity. (This occurs at 5,550 A for photopic vision, but at a shorter wave-length for scotopic or intermediate vision.) The magnitude of the sensation in the eye produced by light of any particular wave-length is not proportional to the luminous flux (power) producing that sensation, so that the relative luminous efficiencies of different wave-lengths cannot be taken as direct measures of the sensations produced by the same power at different wave-lengths. The reciprocal of the efficiency, however, is a measure of the power required at any wave-length to produce the same sensation, i.e., a photometric balance.

(c) The ability of a surface to produce the sensation of light in the eye has for ages been known as "brightness." When precise measurement became possible it was found that surfaces which appeared equally bright under certain conditions might do so no longer if the emissions of luminous flux were reduced equally to a low level, because of a change in the relative luminous efficiency of the radiation. It became essential, therefore, to distinguish between the stimulus and the sensation. *Luminance* is the name given to the physical measure of "brightness," on a linear scale based on the response of the eye in photopic vision. The luminance of a surface is a measure of the luminous flux it emits or reflects, at any level of emission, although coloured surfaces of equal luminance may, at very low flux emission, appear different in "brightness." (See section (e) below.)

(d) Luminous flux obeys all the usual laws of radiation, e.g., linear propagation in a uniform medium. For a source small in comparison with the distance at which a measurement is made, the flux within any cone with apex at the source is therefore substantially constant. The luminous flux density per unit solid angle is then a convenient measure of the illuminating power of the source in any direction; it is termed the *luminous intensity* of the small "point" source in the given direction. It clearly has no real meaning if the dimensions of the source are comparable with the distance at which the measure of illumination is required.

(e) It is desirable to have a term to signify the relative apparent "brightness" of surfaces as viewed, whatever the level of emission or the spectral composition of light may be. (Cf. section (c) above.) The sensation invoked by luminance of a surface is therefore termed *luminosity*. Surfaces of the same luminosity appear to the eye to have the same luminous intensity per unit area, under any circumstances, although the physical measures (luminance) on the linear photometric scale may, in fact, be different.

(3) *Give a brief account of the factors affecting the overall efficiency of a gas source with mantle, showing where these factors are inter-related.*

(*Note*: The student should find it interesting to compare this question and answer with No. 4 of the First Paper and No. 8 (ii) of the Second Paper in the Intermediate Grade examination.)

The first factor which obviously affects the efficiency of a gas source is the composition of the gas used. Even coal gas is not the same everywhere, and other gases are frequently used, e.g., in a caravan or in a portable lantern. However, with a burner designed to supply energy at the correct rate for the mantle in use, normal variations of gas composition or calorific value will have negligible effect.

The complementary factor for proper combustion is the aeration. This itself depends on several factors, such as gas pressure and specific gravity, the form of the injection orifice and the position and size of the ports. Complete combustion is desirable, but the amount of air which can be mixed with the gas before ignition (primary air) depends on the velocity (and so supply pressure) of the gas, since the velocity of flame propagation in the mixture must not exceed that of the flow or the flame will "fire back" to the injector. The proportions of air and gas required for complete combustion depend on the calorific value of the gas, and an empirical formula has been derived; for coal gas with a calorific value of 500 B.Th.U. per cu. ft. closely 4¼ times as much air as gas is required.

Change of specific gravity of the gas (at constant pressure) affects the aeration rather critically, since the rate of gas flow is inversely proportional to the square root of the specific gravity, whilst the primary air intake is unaltered. Whether the temperature of the flame is increased or decreased, the efficiency of light production falls, because the flame size decreases or increases, and the flame no longer fits the mantle for which it was initially adjusted. On the other hand, although change in gas pressure affects both the rate of gas supplied (as the square root of the pressure) and the induced primary air, the air-gas ratio remains approximately constant, and normal variations in gas pressure have negligible effect on the efficiency of the gas mantle; but if a marked change takes place, the efficiency will decrease because, again, the flame will cease to fit the mantle.

Air not introduced as primary air can be obtained from the air surrounding and mixing with the flame (secondary air); but, in general, diminution of the amount of primary air causes reduction in the flame temperature, which reduces the light emission from the incandescent mantle roughly by 10-15 per cent. for 1 per cent. drop in absolute temperature. The amount of ventilation, in particular draught-inducing devices, will influence the aeration markedly; a mantle and burner used in a properly designed fitting may easily give more light than it would in the open air.

The air used for combustion, whether primary or secondary, must be free from the products of combustion already taken place, so good ventilation should be provided within the lantern, and the outlets should be well clear of the intake ports. However, the products of combustion and hot air around the flame may be well used to heat the incoming air supply and the air-gas mixture; such pre-heating may increase the efficiency of the source by some 30 per cent.

The shape and size of the burner influence the efficiency of the gas source; for example, greater air-inducing power is obtained with a sharp-edged injector orifice, but a greater rate of flow of gas with a channel type. A burner that provides minimum frictional resistance to the flow of air and gas is desirable. The shape of the mantle is important, and must be suitable to the flame given by the burner, so that it attains maximum temperature; the mantle and the burner must be considered together, and both in relation to the design of lantern in which they will be used, and the physical characteristics of the gas available.

(4) *What is the evidence that the standard photometric scale of luminance is not linearly related to brightness sensation? Discuss a more likely relation and explain the practical significance of it.*

The most direct evidence is the adaptation of the eye to the general level of luminance; the change in brightness sensation (after the eye is adapted) is not very great for the whole of the photopic range of luminance, some 10^6 to 1, and is nothing like the true luminance range even for scotopic vision, a further 10^6 to 1. Thus one has the impression of seeing nearly as well in a room by artificial light as out of doors in full summer daylight, and not much worse by night on a lighted street, or even by moonlight.

More precise evidence is provided by the limited range of luminances which can be distinguished when any scene is viewed; below a certain level all "shadows" appear black, and above another level all highlights appear dazzling. If the brighter parts of the scene are shielded from view, the gradations in the shadows become apparent, so they are not fundamentally below a threshold of response of the eye. The sensation clearly depends on the general level of luminance in the scene.

The effect can also be demonstrated very easily by gradually diminishing the luminance of a scene, for example

at dusk or by the use of dark glasses. A white surface appears very much brighter relative to its surroundings when the general level is low than when it is high: thus the relative brightness sensation varies with the general level of luminance, although relative luminance remains the same, and the two therefore cannot be linearly related.

The Weber-Fechner law implies that the relationship between the luminance stimulus and the brightness sensation is logarithmic. In fact this appears to hold approximately for normal photopic vision over a range of luminance at least equal to a factor of 10 above or below the adaptation luminance level. For scotopic vision it tends to hold for luminances higher than the adaptation level, but not for lower. Outside the effective range the brightness sensation appears to "flatten out" at either much higher or lower luminance, i.e., the sensation varies little with changing luminance. *Note*: Sketch approximately curves such as Fig. 2.7 of Stevens's "Principles of Lighting.")

The practical significance of such a logarithmic relationship is that an increase in illumination which would be beneficial in a poorly lighted situation would be relatively ineffective in a better lighted one, in which the luminances were already appreciably higher. To obtain equal effect the illumination values must be increased by about the same *proportion.*

(5) *Discuss the visual tasks involved in any* two *of the following games; billiards, table tennis, badminton. Apply the results of these analyses to suggest suitable lighting for the two games chosen.*

(a) In billiards neither fine detail nor movement (at the time of making the cue shot) is involved, and contrasts are generally good, but accurate location of the balls and the pockets is very important. Uniform illumination of the table, not strongly directional, is desirable, because variation in luminance makes judgment difficult; and glare must be avoided, even for a player leaning well over the table. However, a completely diffused light is not satisfactory, as soft shadows and highlights help the judgment of ball positions, and show the entrances to the pockets and the run of the cushions. A suitable arrangement would be a large fitting over the table, combining a high proportion of diffused light with direct light from the lamps and giving a fairly high illumination (at least 20 lm/ft^2) on the table with a rapid reduction beyond the edge of the table. Some additional general lighting of the room should also be provided.

(b) In table tennis the ball is smaller and is in rapid motion when being played, and its flight must be watched very carefully by the player. Although contrasts are quite good, a high illumination is required. Colour is not important, but steadiness of the light is, since variation can make the flight of the ball appear irregular. Shadows and highlights do not play as great a part as in billiards, but again completely diffused light or strongly directional light alone would make judgment of the position of the ball difficult. The lighting can be of the same type as for billiards (with somewhat higher mounting), and the illumination required is of the same order; but special attention must be paid to the avoidance of any effect of flicker if discharge lamps are used on a.c.

(c) The visual task involved in badminton is akin to that in table tennis. The size of detail and the contrasts are similar, and rapid non-uniform movement of the shuttlecock is involved. The main difference is in the height of the shots. As the players will usually be looking upwards rather than downwards, the avoidance of glare is very important. Fittings over the court are likely to be unsatisfactory in this respect; diffusing fittings at the sides of the court (and preferably well outside it) in line with the net provide the best solution, although additional light directed *across* the back of the court may also be used in some situations where the decoration of the hall is helpful. The area to be lighted is the air space above the court, up to at least 20 ft. if this height is available; the surface of the court is less important. An illumination on vertical surfaces of about 20 lm/ft^2 should be provided; steadiness of the light source is essential, and special attention should be paid to the avoidance of glare.

(*Note*: The candidate, of course, should restrict his answer to only two of these three items.)

(6) *Draw a graph showing a typical spectral energy distribution curve for north sky light and comment briefly on the likely changes in this curve with changing conditions of daylight.*

Describe two "colour matching" devices designed to produce a close resemblance to daylight.

Typical spectral energy curves for north sky daylight are given in most books treating on daylight; see for example Fig. 3.11 of Stevens's "Principles of Lighting."

The light originates in the sun and reaches the earth by scatter in the atmosphere. For sunlight the energy per unit wave-length interval is almost constant. However, as the air scatters light of short wave-lengths more than that of long wave-lengths, the skylight from the north quadrant has a relatively high proportion of blue light. Any change in the conditions of daylight will vary the proportion of scattered light of any particular wave-length. Clouds (of relatively large droplets) show little preferential scatter, and dust, smoke or salt particles will affect the scatter distribution. Moreover, the light scattered little by the air has a preponderance of long wave-lengths (as is obvious in a red sunset), and the north sky light therefore tends to contain a less excess of short wave-lengths in the early morning or late evening. (Interesting data are given in a paper by J. N. Hull in Trans. I.E.S. (London), Vol. 19, 1954.)

Note: There are too many "colour matching" units for descriptions to be given here. (See for example Trans. I.E.S. (London), Vol. 16, 1 (1951).) The candidate might select any two from:—

(a) Incandescent filament lamp with blue glass filters,

(b) Carbon dioxide discharge lamp,

(c) Fluorescent mercury vapour tube with special phosphor,

(d) Combination of blue fluorescent tube and incandescent filament lamps,

(e) Xenon discharge lamp,

(f) Crater (but not the flame) of high intensity carbon arc.

(Care should be taken to distinguish between sources used to give a general impression of natural daylight and those suitable for the more exacting requirements of colour matching.)

(7) *By what formula may the apparent intensity of a slowly flashing light be determined? An observer at sea is subject to an illumination at the eye of 0.5 mile-candle from a light visible five times per second with equal light and dark intervals. The true intensity of the light is 10,000 candelas. What is the apparent intensity to the observer? What would be its apparent intensity if the flashing rate were 25 per second?*

The generally accepted formula for the apparent intensity of a flashing light with dark background is

$$I = I_0 \frac{t}{a + t}$$

where I is the apparent intensity and I_0 the true intensity in candelas, t is the length of the time of flash, and a is a constant. Strictly a depends on the illumination produced at the eye of the observer; Blondel and Rey proposed a value of 0.21 sec. for a at the threshold of visibility of the light, but Toulmin-Smith and Green have made an extensive series of measurements at supra-threshold levels, and Hampton has suggested a formula for the relationship.

However, near the practical threshold of conspicuity of the light, a is approximately equal to 0.1 when t is measured in seconds. (Its value is usually taken as 0.1 for an

eclipsed beam and 0.15 for a revolving beam in lighthouses with an eye-illumination of 0.67 sea-mile candela, whilst in aviation a figure of 0.1 is used for eye-illumination 0.5 mile-candela; see B.S. 942-1949 and B.S. 1332-1952.) For the given light, with flash duration of 0.1 sec. therefore,

$$I = 10{,}000 \times \frac{0.1}{0.1 + 0.1} = 5{,}000 \text{ candelas.}$$

If the flashing rate were increased to 25 per second, persistence of vision would come into play, and Talbot's law would apply, viz., that the light appears continuous with value the same as a steady source providing the same total luminous flux to the eye. Its apparent intensity would therefore again be 5,000 candelas, if the light and dark intervals remain equal.

(*Note*: The value to be taken for a is still under discussion internationally, and any value between 0.1 and 0.2 would be reasonable here. The fact that the two intensities calculated above are equal merely implies that the conspicuity of the light would be substantially the same whichever of these flash frequencies was used, although the character of the light would be different.)

(8) *Describe, with illustrations, the following modes of reflection: specular; diffuse; preferential; mixed. Give an example of the occurrence of each of these in natural or everyday objects and an example of each as used in lighting equipment.*

Note: Suitable sketches are given in many text books on lighting; a good form is that of Fig. 6.1 of Stevens's "Principles of Lighting." There are many examples of the different modes to choose from, some of which are given below, but only one of each type is required in the answer.

In *specular* reflection, any small pencil of light remains a small pencil of the same divergence, only the direction being altered (the direction of any ray being determined by the two standard laws of optical reflection); the rays appear to come from an image of the source, real or virtual (which may be distorted if the reflector is curved), and the surface itself has no luminance. General examples are mirrors, polished metal or plated objects, or still water; and in lighting equipment car headlights shop window or street lighting reflectors and stage spotlights.

In *diffuse* reflection the light is scattered by the surface in all directions, so that the surface becomes a secondary source; normally the term is used to imply uniform diffusion, for which the luminance of the reflecting surface is independent of the direction of incidence or of reflection of the light, but depends only on the illumination and the reflection factor of the surface. General examples are snow, plasterwork, unglazed paper; and in lighting, matt projection (cinema) screens, photometric equipment, and studio soft-lights.

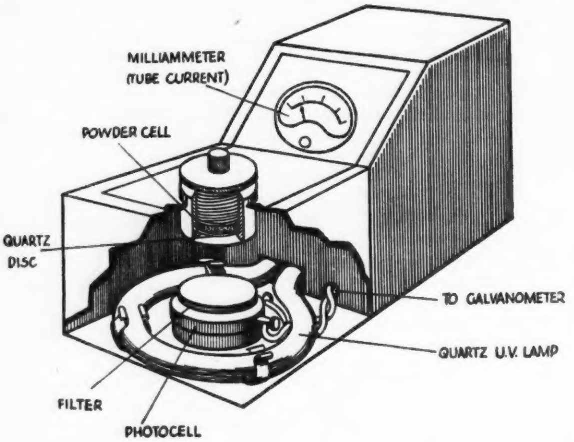
In *preferential* reflection, incident light tends to be reflected in some particular direction, related to the direction of incidence, the luminance of the surface being a maximum in the preferred direction and falling off more or less rapidly in directions inclined to this direction. This is usually (but by no means always) that corresponding to specular reflection. The surface has a sheen; no image is formed, but a soft-edged bright patch on the surface. General examples are most natural materials to some degree, leathercloth, grass; and in lighting equipment lightly diffused polished reflectors, some stoved enamels, and silver or beaded projection screens.

In *mixed* reflection, part of the incident light is reflected specularly and part diffusely. An image of the source is formed by the former component, and the latter gives luminance to the surface itself; the luminance and colour of the former depend on those of the source only, whilst those of the latter depend on the properties of the reflecting surface also. General examples are glazed porcelain, glossy paints or polished wood; and in lighting equipment vitreous enamel and opal plastics.

The Brightness of Fluorescent Powders

The development of fluorescent lamps with higher efficiencies is largely dependent on improvments in the quality of the phosphors used in the fluorescent coating. A simple photometer has been developed at the Research Laboratories of The General Electric Co., Ltd., to measure the comparative luminances of phosphors. It is used not only in laboratory experimental work, but also for routine factory testing of batches of phosphor. Its repetition accuracy is within 2 per cent.

The photometer consists essentially of a cubical box with a totally black inner surface and a small circular hole in the centre of a hinged lid. Short wave ultra-violet radiation is provided by a low-pressure mercury vapour discharge in a quartz tube. This tube is bent into a circular shape round a photocell. The photocell is of the rectifier type and is



covered by a filter which gives it an approximate "average eye" response. The tube and photocell unit are mounted in the base of the box with their centres vertically below the lid aperture. This arrangement ensures that no direct light from the ultra-violet tube falls on the photocell.

One of the main problems in comparing the luminances of different phosphors is to obtain a standard fluorescing surface. This has been solved by designing a standard circular glass box or "cell" which holds about 5g. of the phosphor. When the lid of the cell is screwed down, the powder is compressed into a layer 1-2 mm. thick and a uniform and repeatable surface is obtained on the transparent window in the base of the cell.

For rapid comparison of luminances, two such cells are used, both having crystal quartz windows. One cell is filled with the powder under test and the other with a standard material. This is a phosphor which is of the same colour, type and general composition as that under test. The test procedure is to place first the cell containing the standard, and then the cell containing new powder into the upper hole in the photometer. The ultra-violet radiation which reaches the window of each cell causes the powder to fluoresce. As the fluorescent light falls on the photocell, the different currents produced, which are dependent on the luminance of the phosphor layer, are read off on a galvanometer.

A correction for the small quantity of visible light (about 30 per cent) emitted by the ultra-violet lamp and reflected from the surface of the phosphor is made by use of a third cell.

Situations Vacant

Well-known manufacturers have a vacancy for a YOUNG MAN to plan, and ultimately take charge of, a section manufacturing discharge lamp control gear. Practical experience of design and/or production of this similar equipment essential. Excellent conditions of employment and social facilities.—Apply, giving details of age, training, experience, etc., to Box No. 899.

A leading electrical and electronic engineering company in London wish to fill the following drawing office vacancies:—(a) COMPONENTS DRAUGHTSMAN with O.N.C. standard education and experience in radio or light mechanical engineering. (b) LIGHTING FITTINGS DRAUGHTSMAN with experience of sheet metal work, lighting design and electrical wiring. For both positions training will be given and young men with useful but not related experience will be considered. In addition to good starting salaries, the company offers excellent staff conditions, pension scheme, canteen, etc. Apply to Personnel Officer, Century House, Shaftesbury Avenue, London, W.C.2. Telephone No. Gerrard 7777.

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STREET LIGHTING ENGINEERS (2 or more) for preparation of tenders at the Head Office (London), British Thomson-Houston Co., Ltd. (Reference PGB), 44, Fitzroy Road, London, N.W.1.

Agency

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Trade Literature

BENJAMIN ELECTRIC LTD., Tottenham, London, N.17.—New outdoor catalogue, covering the complete range of fittings for outdoor lighting, giving full details and prices.

THORN ELECTRICAL INDUSTRIES LTD., 105-109, Judd Street, London, W.C.1.—Leaflet giving the facts and figures behind the outstanding performance of "Atlas" fluorescent lamps.

J. A. CRABTREE & CO. LTD., Lincoln Works, Walsall, Staffs.—Illustrated catalogue giving details and prices of numerous flush switches for the contemporary interior. Also a new complete price list, No. 195, of all this company's electrical products.

THE BRITISH THOMSON-HOUSTON CO. LTD., Crown House, Aldwych, London, W.C.2.—Leaflet describing the "Mazda Monolux" tapered fluorescent batten fittings, giving details and prices. Also well illustrated catalogue giving full details and prices of all "Mazda" projector and photographic lamps.

BERRY'S ELECTRIC LTD., Touchbutton House, Newman Street, London, W.1.—Envelope containing catalogues illustrating decorative lighting fittings. This includes list No. 5531, giving details and prices of contemporary fittings; list No. 5532, dealing in the same way with period-style fittings; and list No. 5533, which illustrates fittings of hewn oak and wrought iron. Also a small leaflet giving details of the "Adjustalamp."

KNIGHTSHADES LTD., Montagu Road, Edmonton, London, N.18.—Illustrated catalogue giving full details of a wide range of new designs for table lamps, bedlights, and lamp shades including "Nylux" shades.

HOLOPHANE LTD., Elverton Street, Westminster, London, S.W.1.—New catalogue of commercial lighting fittings covering offices, shops, banks, churches, schools, municipal buildings, libraries, hotels and restaurants. Full details in all cases, plus a section dealing with "In-Bilt" units.

Personal

MR. H. H. HATTON has been appointed assistant manager of the Liverpool branch of The General Electric Co., Ltd.

At a meeting of the Council of the International Electrotechnical Commission held at British Standards House on July 8, DR. PERCY DUNSHEATH was unanimously elected President of the Commission, to succeed DR. HAROLD S. OSBORNE, whose three-year term of office had expired.

Ekco-Ensign Electric Ltd., announce the recent appointment of MR. H. J. PRICE as their representative covering Oxfordshire, Berkshire and Buckinghamshire, and MR. B. A. EDENBOROUGH, who will cover the south-west of London area. They will operate from the company's southern sales office at 45, Essex Street, Strand, W.C.2.

Frontispiece

The picture on page 296 shows the central area of London Airport between the passenger handling building and the control tower. The open space where cars and coaches are parked is lighted by means of G.E.C. "Three-eighty" cut-off lanterns each containing three 5-ft. 80-watt fluorescent lamps mounted at 30 ft. This provides good visibility for road users without interfering with that of pilots.

A Cure for Falling Turnover

GENERAL TRADE CLEARINGS, LTD., 82-90, Seymour Place, London, W.1, Tel.: PADdington 3456, invite manufacturers of lighting and general industrial electrical equipment to send to them details of their products for possible inclusion in the G.T.C. Industrial Catalogue which has a circulation of 350,000 entirely in Great Britain and is read by those in industry only, seven times per annum. A copy of the catalogue will be gladly sent to anyone interested.

POSTSCRIPT By "Lumeritas"

An almost unbelievable event has occurred in a London hospital; a man has died—in the words of the coroner—"under circumstances when he could not be seen." The man had undergone an operation and, after being returned to the ward from the operating theatre, he was watched by a nurse, as is the usual practice. After about five minutes the nurse noticed the patient's ear turning blue and called the doctor, who came immediately but found the patient dead. Giving evidence at the inquest the doctor said, "The lighting was exceedingly dim. It was only gross changes in the man's colour that could be distinguished. The lighting in that particular ward is quite inadequate." The coroner said that the deceased had suffered some obstruction in the throat which had caused asphyxia, and he added, "I have no doubt that this could always happen with the lighting described." It is hard to understand how such inadequate lighting could be tolerated in a hospital ward to-day, and it is to be hoped that nothing like it is to be found in any other of our hospitals. During the last war the relighting of one of our factories led to the discovery of items of equipment which it was said had not been seen for years because certain parts of the factory had been so dimly lighted. This was extraordinary enough, but the present case is still more extraordinary and, of course, far more serious. Fortunately, considerable progress in hospital lighting has occurred since the war, and this was reported at the recent meeting of the Commission Internationale de l'Eclairage in Zurich. It appeared from this report that so much is known about how hospitals should be lighted that it was decided that the C.I.E. need not pursue this subject during the next inter-sessional period. Notwithstanding this, it was recommended that national committees should continue to study certain aspects of hospital lighting. Towards the end of July an impressive volume entitled "Studies in the Functions and Design of Hospitals" was published by Geoffrey Cumberlege at the Oxford University Press, and this includes an excellent section dealing with the daylighting as well as the artificial lighting of hospitals. The volume is a report of a team sponsored by the Nuffield Provincial Hospitals Trust and the University of Bristol.

Writing to the Editor last month Mr. R. R. Holmes suggested that what he termed the "Footcandlers" and the "Lumens-per-square-footmen" might agree to accept their lumen per square foot as the *unit* of illumination and footcandle as the *name* of this unit. "Footcandle," he argued, "is still much the more readily spoken term and, through its long associations, universally understood." Among "old-stagers" there is no doubt that it is universally understood, but neither this nor the fact that "footcandle" is easily said seem very good reasons for its retention. After all, "footlumen" is just as readily spoken as "footcandle" and is a name manifestly derived from the definition of the unit, whereas "footcandle" is a rank outsider, at least to the uninitiated. Moreover, to lighting users—most of whom are uninitiated—the candle is only understood in its tangible form and "footcandle" is a word whose meaning can be misunderstood as well as merely not understood. On the other hand, the lumen is intangible and "footlumen" is suggestive of no known ancient or modern light source. However, I am not proposing the use of "footlumen," but is not "footcandle" out of order anyway—should it not be "footcandela"? And would Mr. Holmes have us speak of an illumination of *n* footcandelas or of *n* footcandlae? Would he number himself among the "Footcandelars" or the "Footcandelaists"? I think there is little doubt that had we appropriated the name "lux" before the unit of illumination in the metric system was so named no one would ever have championed "footcandle." Having missed our chance of using "lux"—until we adopt the metric system—no similarly short name for our own unit of illumination has received any serious consideration, still less general approbation. The search for, and advocacy of, such a name seems more worth while than any effort to give "footcandle" a new lease of life.

Statutory requirements for reasonably good working conditions in places of employment now have very limited application, since the creating Acts—the Factory Acts and the Mines and Quarries Act—do not relate to the various other establishments in which people are employed. The Home Secretary has recently made it clear that the Government intends to deal with this situation by introducing further legislation during the life of the present Parliament. Thus it is likely, in the near future, that there will be legal requirements respecting the lighting of offices, shops, restaurants and other places of employment. While it is likely that many of these places already have standards of lighting higher than any statutory minima which may be laid down, it is only right that powers should be taken to enforce improvement of conditions wherever bad conditions are found.

At the recent annual conference of Scottish opticians, held in Aberdeen, Mr. J. Lindsay, M.A., F.B.O.A., gave a lecture in which he dealt with several aspects of the work of ophthalmic opticians which are not always given due attention. He mentioned particularly the subject of lighting. Until a few years ago little or no technical study of lighting and its relation to vision was done by student opticians, but it is now a compulsory subject and candidates taking the final professional examination of the British Optical Association are examined in it. As Mr. Lindsay pointed out, this part of the training of opticians is not merely of academic value, for the visual problems with which opticians have to deal may often be partly due to a faulty lighting environment. The new generation of ophthalmic opticians should be qualified to give their patients good advice about lighting when this seems necessary for their comfort and ease of seeing. The ophthalmic optician is extremely well placed to encourage the use of good lighting, especially in the home, and if he keeps in touch with the subject—as he easily may through this journal—he can do much good.

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